

**WAGES AND JOBS:
ESSAYS IN LABOUR DEMAND**

By Declan Trott

**A thesis submitted for the degree of Doctor of
Philosophy of the Australian National University.**

30 July 2010



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ESSAYS IN LABOUR DEMAND

By Bochna Trott

A thesis submitted for the degree of Doctor of
Philosophy of the Australian National University

20 July 1970

CANDIDATE'S STATEMENT

This thesis is my own original work.

A handwritten signature in black ink, consisting of the letters 'A', 'L', and 'H' in a stylized, cursive-like font. The 'A' is large and loops around, the 'L' is tall and thin, and the 'H' is also tall with a horizontal crossbar.

31/3/11

(Library copy, with revisions)

ACKNOWLEDGEMENTS

The main thanks must go to my supervisor Paul Chen, for his tireless encouragement, editing and devil's advocacy. Thanks also to panel members past and present: Heather Anderson, Robert Breunig and Andrew Leigh; and Bob Gregory for setting the ball rolling.

I would also like to acknowledge helpful comments from the following individuals: Alison Booth, Tim Bradley, Antonio Ciccone, William Coleman, Tanuja Doss, Steve Dowrick, Shane Evans, Dana Hanna, Thomas Lemieux, and Russell Ross. And a collective thanks to seminar participants from the School of Economics and Research School of Social Sciences at ANU, and the 2008 PhD Conference in Economics and Business.

And, of course, thanks to my family for all their support.

ABSTRACT

This thesis contains four essays, of varying length, on the general theme of labour demand. An initial Overview describes the subjects of the different essays, and the links between them. Each essay also contains its own, more detailed, abstract.

Part A considers the question ‘Why Has Wage Inequality Risen Most Where Wage Shares Have Fallen Least?’ In recent decades, most developed countries have experienced rising wage inequality and falling wage shares. The same causes have often been blamed for both trends. It is observed, however, that wage inequality has risen the most in those countries where wage shares have fallen the least, and vice-versa. The majority of existing theories are either theoretically or empirically unable to explain this puzzling relationship, which deserves much more attention than it has received.

Part B combines the two shortest essays, ‘A Note on the Elasticity of Demand for Homogenous Labour’ and ‘A Note on Immigration and Average Wages’. These argue, respectively, that commonly used labour demand elasticity formulae derived from the microeconomic conditions of a single industry are inappropriate for most macroeconomic applications, and that immigration should be considered as a shock to the growth rate of the labour force, rather than its level.

Part C asks ‘Why Don’t Relative Wages Affect Employment (Very Much)?’ It argues that several common explanations for these findings lack sufficient evidence to be persuasive, and proposes an alternative: that the demand for labour is much less elastic at the occupational level than at the aggregate level. This hypothesis is shown to

be consistent with a range of stylized facts about the labour market, while the rival explanations are not.

The Last Words offer some reflections on the findings, both empirical and theoretical, of the preceding essays, and their more general implications.

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OVERVIEW

One might be forgiven for thinking that labour demand is presently something of a backwater in economics. It doesn't even rate an entry in the New Palgrave Dictionary of Economics. The basic theory of labour as a derived demand is a simple combination of the most fundamental consumer and producer theory. Surely the subject was given its canonical treatment by Hicks' *Theory of Wages* in 1932, and wrapped up by Hamermesh's *Labor Demand* in 1993? Perhaps there remain some arguments about the exact value of particular elasticities, the length of the appropriate adjustment times, or the effects of technological change. Yet this hardly adds up to a situation of basic uncertainty in which the big questions are yet to be answered.

Despite this state of academic quiescence, however, on practical questions debate is still very much alive. We worry about rising wage inequality and falling wage shares, but we are uncertain about the causes and even more so about the remedies. There is still heated argument over the effects of minimum wages and immigration. And even theoretically, we seem unsure of the applicability of the most basic assumptions underlying what we think we know. Perhaps employers are not price-takers in the labour market, or a worker's marginal productivity is a function of the wage as well as vice-versa. This thesis attempts to explore some of these still unanswered questions, to offer some answers, or at least define more clearly what problems need to be solved.

Part A, 'Why Has Wage Inequality Risen Most Where Wage Shares Have Fallen Least?' considers a puzzling and under-appreciated feature of the modern labour

market. In recent decades, most developed economies have experienced rising wage inequality and falling wage shares. Both trends, particularly the rise in inequality, have received a large amount of attention in the literature. Moreover, the same list of culprits commonly gets the blame: globalisation, technological change, and the weakening of labour market institutions. Yet it has not been widely observed that the increase in wage inequality has been the largest in those countries where the fall in the wage share has been the smallest, and vice-versa. This observation makes it difficult to blame both trends on the same set of forces.

After documenting and checking the robustness of this surprising correlation, the essay develops two theoretically consistent explanations: one based on capital accumulation, and the other on the behaviour of the highest labour incomes. The empirical evidence, however, is not found to be particularly supportive of either. It also becomes evident that the changes in the wage share are much harder to explain than the changes in wage inequality. These results clearly point to an important and neglected phenomenon which current theory struggles to rationalise.

Part B consists of 'Two Notes on Labour Demand'. The first Note takes up a recent debate over how to turn elasticities of substitution between capital and labour into elasticities of demand for labour suitable for use at a macroeconomic level. It argues that standard microeconomic formulae are only applicable at a larger scale under very special conditions. The other enters the controversy regarding the effect of immigration on the wages of native workers in the host country. It is suggested that, along with the effect on relative wages emphasised by recent literature, there is a potentially significant effect on average wages when immigration is considered as a more rapid rate of growth in the labour force, rather than a level shock.

Part C, ‘Why Don’t Relative Wages Affect Employment (Very Much)?’, considers the employment penalties (or lack thereof) of minimum wages and other institutional wage floors affect. There is a large amount of evidence showing that the employment penalties of these interventions are small or nonexistent. The common reactions to this evidence are either to question its validity, or to throw out the price-taking, market-clearing ‘neoclassical’ model of the labour market and replace it with something else. As suggested above, monopsony and efficiency wage theory are popular candidates, along with aggregate demand. The approach taken here, by contrast, is to take the evidence seriously, but to seek for an explanation in the substitution possibilities (or lack thereof) inherent in production technology and consumer preferences, rather than some peculiar feature of the employment relationship or the labour market in general. In particular, it is useful to consider the demand for labour in particular occupations, rather than for particular personal characteristics – to focus on the job to be done rather than the worker doing it. Under the hypothesis that the demand for labour at this level is highly inelastic, a range of otherwise puzzling features of the labour market can be explained.

Besides the overarching theme of labour demand, it will be seen that Part C relies on empirical and theoretical results from Parts A and B. In particular, the model of capital-skill complementarity from chapter A3, the empirical results from chapter A4, and the elasticities of labour demand from chapters B1 and B2 are all used. It should also be noted that, because of the unequal size of the different essays, they have been treated somewhat differently when converted into thesis form. Part A is in fairly conventional article format, with each section simply turned into a chapter. The two shorter papers in Part B are each presented complete in a single chapter. Part C is

presented as a short monograph, with a somewhat more discursive introduction and conclusion, and other chapters containing their own brief introduction and summary.

PART A

WHY HAS WAGE INEQUALITY FALLEN MOST WHERE WAGE SHARES HAVE FALLEN LEAST?

In recent decades, most developed countries have experienced rising wage inequality and falling wage shares. Both trends are often blamed on globalisation, technological change, and weakening labour market institutions. This paper shows, however, that wage inequality has risen the most in those countries where wage shares have fallen the least, and vice-versa. A range of potential explanations are considered. As part of this, a new production function which combines capital-skill complementarity with an easy to calculate labour share is developed, and bottom 99% wage shares are calculated from newly available top incomes data. These and other existing theories, however, seem empirically unable to explain this puzzling relationship.

CHAPTER A1. INTRODUCTION

Wage inequality has risen considerably in many developed countries over the last few decades. The causes of this rise have been the subject of much debate, especially in the United States, where the trend has been particularly strong. Initially, expanded international trade and capital mobility were the main suspects. As the debate evolved, the focus shifted towards skill biased technical change and capital accumulation. More recently, the weakening of labour market institutions such as unions, minimum wages, and social norms for executive pay have received attention, as has the role of immigration. All of these interpretations still have their defenders and detractors – see Gordon and Dew-Becker (2008) for a survey, or Machin (2008) for a more international flavour.

In the same period, the share of wages in gross domestic product, i.e. the labour share, has been falling in many countries, particularly in continental Europe. Interestingly, proposed explanations fall into much the same categories as those for increasing wage inequality: globalisation, technology, and institutions (e.g. Jaumotte and Tytell 2007, Blanchard and Giavazzi 2003).

It would seem natural to consider these two trends together rather than separately. After all, they are both outcomes of the same structural processes: the interactions among labour supply, labour demand, and institutions that determine employment and wages. Moreover, exactly the same theories have been advanced to explain both rising wage inequality and falling wage shares. Yet these phenomena have very rarely been analysed jointly. Checchi and Garcia (2005, 2008) are an exception,

integrating both wage inequality and the wage share in their analysis of overall income inequality. They do not, however, make any specific comparison of the trends in wage inequality and wage shares across different countries. Such a comparison is the starting point for this paper.

Chapter A2 describes recent changes in wage inequality and wage shares, and more importantly, the relationship between those changes. In a sample of eleven OECD countries from the 1970s onwards, wage inequality has risen in most countries, and the wage share has fallen in all. Surprisingly, however, wage inequality has risen the most in precisely those countries where wage shares have fallen the least, while wage shares have fallen the most where inequality is stable or even falling. This pattern is hard to reconcile with the claim that the same forces are largely responsible for both rising wage inequality and falling wage shares.

Individually, these country differences have not gone unnoticed in the literature. While the emphasis has been on rising wage inequality in the United States and falling wage shares in Europe and elsewhere, there has been some discussion of the dogs that did not bark – stable European wage inequality and the muted fall in the wage share in the US. Since inequality and shares have been discussed as separate subjects, however, the full significance of these facts has perhaps not been appreciated. Hornstein, Krusell and Violante (2002) mention the contrasting trends in the two variables, but only for the United States compared to continental Europe as a whole, and the observation did not survive the transition from working paper to journal article (2007). This paper, by contrast, shows that the relationship holds for a sample which includes several continental countries individually, as well as other English-speaking and Asian economies, and argues that it is an important puzzle to be solved before any explanation of the individual trends can be truly convincing.

Chapter A3 then contrasts this finding with the explanations for rising wage inequality and falling wage shares given in the literature. Some of these – globalisation, technology, institutions and education – seem to imply that higher inequality should be correlated with lower wage shares, since they are cited as causes of both trends. Other factors such as capital accumulation, top wages, product market competition, and vintage capital, seem more promising as an explanation of our puzzle, since they at least have the potential to move wage inequality and wage shares in the same direction.

Along with an assessment of the explanations offered in the literature on these topics, this chapter presents a new theoretical framework for the analysis of capital-skill complementarity, and an alternative measure of labour incomes. Firstly, a two-level, 3-factor modified CES production function is introduced, which combines capital-skill complementarity with a simple expression for the wage share. Previous production functions have generally had one or the other property, but not both, making them difficult to use when analysing both phenomena simultaneously. Secondly, extending the work of Glyn (2009) for the United States, bottom 99% wage shares are calculated for eight OECD countries using top incomes data collected in Leigh (2007). This measure gives a better picture of what is happening to the mass of labour incomes than wage shares inclusive of the highest earners, whose incomes have expanded dramatically in some countries, and should arguably be placed in a different category.

Chapter A4 brings these different explanations together using panel regressions. The main aim is not to differentiate between the variables individually (although some attempts are made in this direction), but to see whether, as a group, they can explain the puzzle documented in chapter A2, at least in an accounting sense. Equations for wage inequality and wage shares are estimated jointly using seemingly unrelated regression, and both the levels of and changes in the residuals are tested to see whether there is

some relationship between wage inequality and wage shares that is not being captured by the standard set of regression variables.

The main findings are that the changes in wage inequality across countries are much better explained by our set of explanatory variables than the changes in wage shares, both in terms of statistical fit and theoretical plausibility. Furthermore, the puzzle is only ‘explained’ to the extent that there is a correlation between lower wage shares and a higher level of educational attainment. When this variable alone is removed from the analysis, or an alternative measure of education is used, the correlation between higher wage inequality and higher wage shares is almost as strong as in the raw data, and most of the models’ explanatory power over changes in the wage share disappears. The bottom 99% wage shares calculated in chapter A4 show smaller absolute differences between countries than the full wage share, but they do not seem to diminish the strength of the correlation between inequality and shares. Chapter A5 recapitulates these findings and sets forth some tentative suggestions for further work.

CHAPTER A2. THE PUZZLE

We begin with a description of recent trends in wage inequality and wage shares, and the relationship between them. Our data covers eleven countries: Australia, Denmark, Finland, France, Japan, (South) Korea, the Netherlands, New Zealand, Sweden, the United Kingdom and the United States. These are the only countries for which both variables of interest are available from at least the 1980s onwards, which unfortunately excludes significant economies such as Canada and Italy. Germany is also excluded because of the problems of accurately accounting for reunification. The wage share is from the European Commission, and is adjusted for self employment and nonwage compensation. The wage inequality measure is the ratio between the 9th and 1st full-time earnings deciles, for both sexes combined, from the OECD. (Note that, since the ratio is based on full time earnings, it should not be affected by changes in hours worked.) A more detailed description of these and all variables used subsequently is given in the Data Appendix which follows chapter A5.

The progression of *wage inequality* (as measured by the 9th/1st earnings decile ratio, henceforth 9/1 decile ratio) over time is shown in Figure A.1. It is rising over time or stable in most countries, except for France, where it has declined, and Korea, which shows a striking U-shaped pattern. There is also a great range in levels, from around 2 in Finland and the Netherlands to nearly 5 in the United States at the end of the sample. The Korean data seems somewhat dubious in its uniformity early in the period.

The *wage share* is shown below in Figure A.2. Across the whole sample, it is generally falling almost uniformly for the period shown. Again, Korea stands out, this

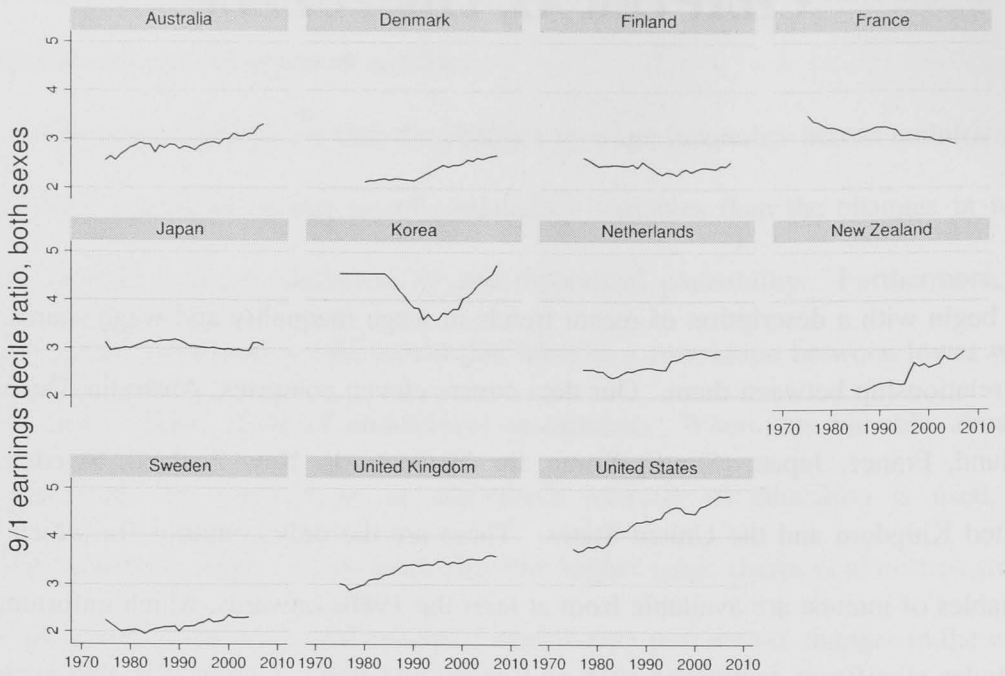


Figure A.1: Wage inequality, 1975-2007.

time for the extremely high level of the wage share. By contrast, the wage share in New Zealand is unusually low, averaging below 50%. The importance of agriculture in this economy may lead a high proportion of land rents in income, or a high level of self-employment which would amplify any imperfections in the relevant adjustment.

Whatever the reasons that cause the levels of the wage share in Korea and New Zealand to be unusual, we will see that the changes over time seem to be within the range of the rest of the sample. Since the analysis in this and subsequent chapters relies upon first differences, time trends and country fixed effects, rather than the absolute level of the wage share, these countries were retained, at least for some purposes.

The focus of this paper, however, is not the trends in wage inequality and wage shares individually, but rather how these trends relate to each other. Figure A.3 plots the changes (first differences) in these variables for each country from 1980 to 2000.

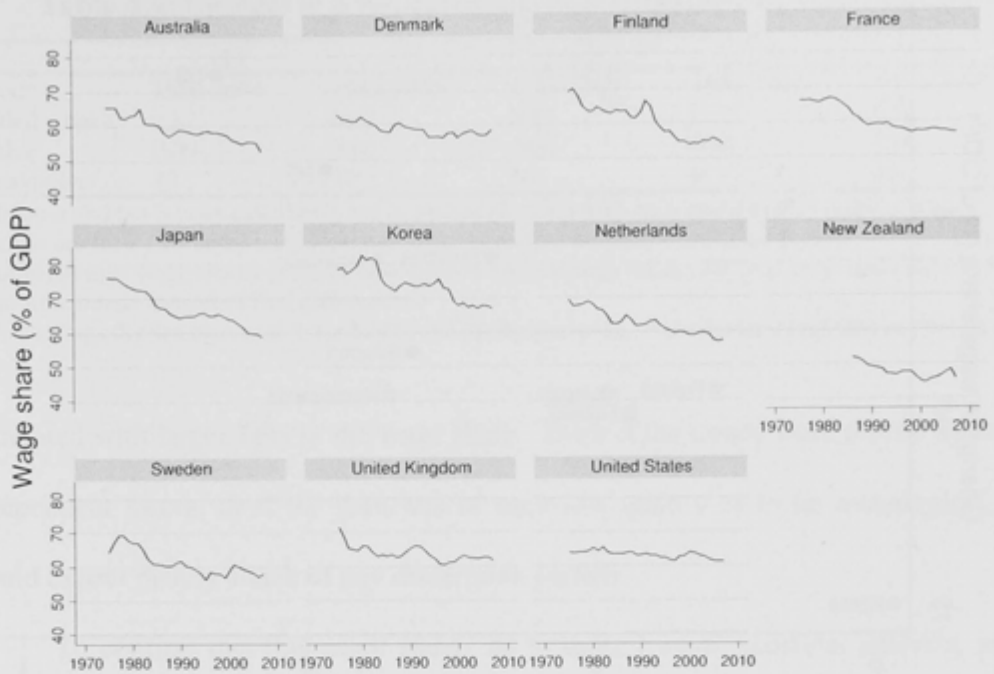


Figure A.2: Wage shares, 1975-2007.

The results are clear cut, and on reflection, surprising. Where wage inequality has risen the most, in the United States, the wage share has fallen the least. By contrast, wage inequality has been stable or even falling in Korea, Japan, France and Finland, which have experienced some of the largest falls in the wage share. The size of the differences are not trivial, either: the wage share has fallen by nearly ten percent of GDP in these countries (15% in Korea), while in the United States, the fall was just over three percentage points. Wage inequality, as measured by the 9/1 decile ratio, fell by 0.2 in France and over 0.5 in Korea, while it rose by 0.7 in the United States. Compare this to the unweighted arithmetic means of the two changes, which are an increase of 0.2 for the decile ratio and a fall of nearly 8 percentage points for the wage share. The variation between countries is clearly larger than the overall trends which have received

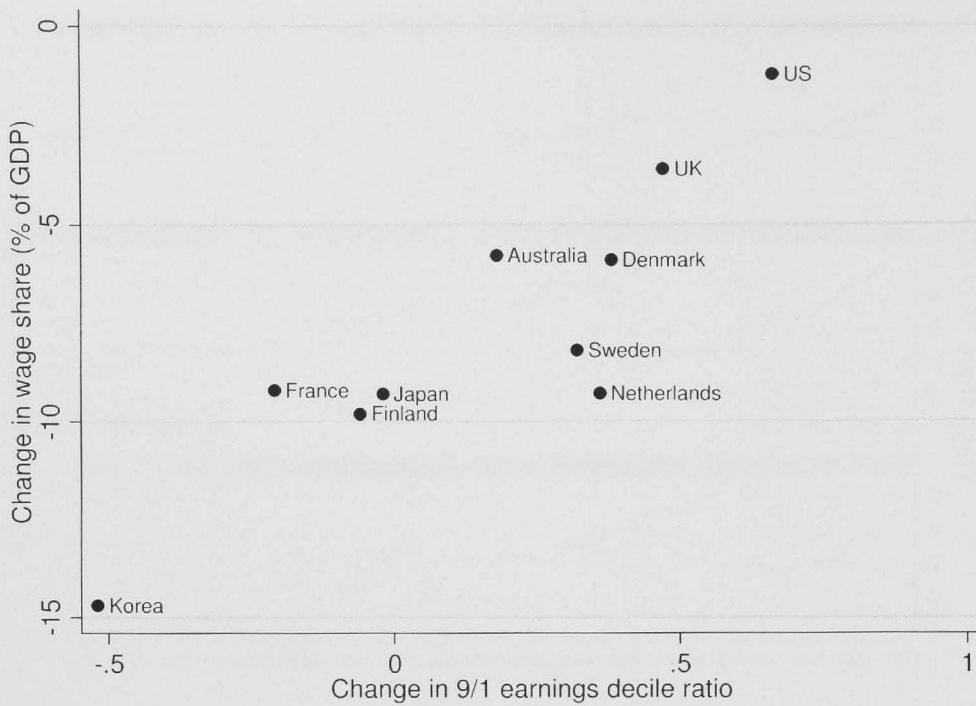


Figure A.3: Changes in wage inequality and wage shares, 1980-2000.

so much attention. One may roughly say that the English-speaking economies have seen bigger rises in wage inequality and smaller falls in the wage share than continental Europe and Asia, but the relationship seems to hold within these groups as well as between them. Compare, say, Australia to the UK and US, or Denmark to the rest of Europe.

Why is this so surprising? If rising wage inequality and falling wage shares were being driven by the same forces, such as a common shock from globalisation or technological change, and these forces were similar in their impact across countries, one would expect all countries to have a similar experience: Figure A.3 should be a single dot, or tight ball. If the same forces were at work, but operating with different strengths or timing across countries – some countries may be more or less open to the world economy, adopt new technology at a different pace, or have different institutions – Figure A.3 should slope in the opposite direction, with large rises in wage inequality

Table A.1: Changes in wage shares and wage inequality, rank correlations.

	(1)	(2)	(3)	(4)	(5)
Period	1980-2004	1980-2000	1980-2004	1980-2004	1975-2005
Kendell's tau-a	0.82	0.67	0.82	0.79	0.71
P-value	0.00	0.00	0.00	0.01	0.00
Observations	10	10	10	8	11

Both tau-a and tau-b were calculated, but in almost all cases they were equal to two decimal places.

P-values are for a two-tailed test of the null hypothesis that the rank correlation is zero.

Column (3) uses wage shares at factor cost, column (4) earnings deciles for men only, and column (5) linear time trends instead of first differences.

Male earnings deciles unavailable for Korea and the Netherlands. New Zealand included in time trend.

correlated with larger falls in the wage share. Even if the trends were driven by totally independent forces, or if the data was of such low quality as to be meaningless, one would expect merely a lack of any discernible pattern.

To confirm that this result stands up to more formal statistical analysis, and is robust to the choice of time period and data, we use Kendall's tau rank correlations² and several variations on the specification in Figure A.3: 2004 instead of 2000 as an end point (the longest time period for which data is available for all countries except New Zealand), linear time trends (fitted by ordinary least squares) for the period 1975-2005, earnings deciles for men only rather than both sexes,³ and wage shares measured at factor cost instead of market prices. While there are minor differences between these specifications, as can be seen in Table A.1, the central finding is robust: a strong positive correlation at a very high level of statistical significance.⁴ Indeed, the correlation (as well as the absolute size of the changes) is even stronger over the longer time periods 1980-2004 and 1975-2005. The period 1980-2000 is used in Figure A.3

² Kendall's tau is calculated according to a formula based on the rank order of the observations. It is more robust to outliers and non-linear relationships than the standard correlation coefficient, but the interpretation is still +1 for a perfect positive correlation, -1 for a perfect negative correlation and 0 for a complete lack of correlation. See e.g. Kruskal (1958) for further discussion.

³ The only justification for not using both sexes combined is that the composition of the labour force may have changed with the increased employment of women. Under this scenario, the female earnings deciles would be affected by composition effects, and therefore not as useful.

⁴ As shown in chapter A4, this result is also robust to dropping Korea from the sample. Note also that a positive correlation between *changes* in wage inequality and wage shares is equivalent to the more intuitive statement that wage inequality has *risen* the most where wage shares have *fallen* the least.

only to facilitate comparison with the top incomes data later in the paper.

Table A.2: Changes in wage shares and wage inequality (shorter periods).

	(1)	(2)	(3)	(4)
Period	1980-1990	1990-2000	1990-2004	1980-2000
Kendell's tau-a	0.20	-0.07	0.05	-0.09
p-value	0.47	0.81	0.88	0.79
Observations	10	11	11	10

Column (4) uses differences-in-differences for 1990-2000 vs 1980-1990.

The result is not so robust, however, when shorter time periods are used. As reported in Table A.2, when the sample is split into two ten year periods 1980-90 and 1990-2000, the rank correlation between changes in wage inequality and wage shares in different countries becomes statistically indistinguishable from zero. The same is true when the later period is extended to 2004, and when differences-in-differences is used to examine the within country variation across the two time periods. The differences-in-differences are calculated as $(y_{2000}-y_{1990})-(y_{1990}-y_{1980})$, where y is wage inequality or the wage shares for the given year. Whereas the simple changes and time trends focus on between country variation in a single time period, the differences-in-differences approach measures whether, for each country, wage inequality rose more or less in those periods where wage shares fell more.

Why does the correlation that is so strong over the full length of our data become so weak in the shorter sub-periods (i.e. at higher frequencies)? This depends on what is driving the correlation, which is almost certainly spurious in the sense that a direct causal relationship from wage inequality to wage shares, or vice-versa, is extremely unlikely. It is more plausible that there was some common force pushing wage inequality and wage shares in the same direction, or that the forces causing rising wage inequality and falling wage shares were distinct, but happened to vary inversely in strength across countries so as produce the pattern we observe. If a common force did exist, the results for the sub-periods may be biased towards zero by measurement error,

which is more significant when the true changes are smaller, or we may be confounded by temporary cyclical disturbances, which are also likely to be more important over a shorter period. If the forces were distinct, then both the sub- and full period results simply reflect whatever was happening to the separate forces in each period. Of course, the two options are not mutually exclusive.

We are still left, however, with the fact that wage inequality rose the most in those countries where wage shares fell the least, and vice-versa, over a period of twenty years and more. It is not the purpose of this paper to argue that this is a general law true for all countries, in all time periods, and at all frequencies. Rather, it is to document the pattern as a historical fact, and explore its implications for various theories which have been put forward regarding its constituent phenomena. For this purpose, the observation that the pattern becomes weaker at higher frequencies is interesting, perhaps, but not of overwhelming importance. If we wish to explain why wage shares tended to fall and wage inequality tended to rise in developed countries around the end of the twentieth century, our theory should be consistent with the fact that the strength of those two trends was inversely correlated across countries. As we shall see in the next chapter, this is not a trivial challenge.

CHAPTER A3. SUGGESTED EXPLANATIONS

In our sample of OECD countries over the last few decades, wage inequality has generally been rising and wage shares falling. We have seen, however, that the rise in wage inequality has been largest in those countries where the fall in the wage share has been the smallest, and vice-versa. Keeping this result in mind, we now discuss various causes that have been proposed for rising wage inequality and falling wage shares, and focus on whether they can account for the negative correlation between the two trends.

While the wage inequality literature is vast, its main themes are fairly few. The following discussion relies on the surveys of Gordon and Dew-Becker (2008) and Machin (2008). Since the wage share literature is smaller, relevant papers are cited individually. It must be emphasized that the following is a description of common arguments that have been put forward in the literature, not an endorsement of them. Many, if not most, have been criticized on empirical or theoretical grounds.

We begin with globalisation, technology, and institutions. These three are probably the most common suggested causes of rising wage inequality and falling wage shares. Precisely because they are used to explain both trends, however, they seem unpromising candidates to explain our puzzle. The same comment applies to education. We then move on to other causes – capital accumulation, the movement of top labour incomes, product market regulation and vintage capital – which have more potential to move wage shares and inequality in the same direction, or at least affect one while leaving the other unchanged. The section on capital accumulation introduces a novel production function which combines capital-skill complementarity with a simple

expression for the wage share, and bottom 99% wage shares for eight countries are calculated as part of the discussion of top labour incomes.

Globalisation is a catch-all term used to cover increases in capital mobility, international trade, and immigration, since both the logic and effects are similar. In all cases, globalisation tends to help the relatively abundant factor, and hurt the relatively scarce factor. This may be through factor mobility directly changing relative factor supplies, or through trade replicating these effects according to the Heckscher-Ohlin theorem. As Jaumotte and Tytell (2007:5) put it: “the effective global labor supply quadrupled between 1980 and 2005 . . . Advanced economies can access this increased pool of global labor both through imports of goods and services and through immigration.” In the case of a developed country, capital is abundant relative to labour, and skilled labour relative to unskilled. Therefore, it is argued, globalisation will reduce the wage share and increase wage inequality. Making these assertions simultaneously would logically require a 3-factor model, but since they are usually presented separately, 2-factor logic usually prevails. Some complications of the 3-factor setting are explored below in the section on capital accumulation. Another caveat is that factor mobility would not necessarily lead to a change in the wage *share* of GDP, as opposed to wage *rates*, depending on the elasticity of substitution between capital and labour. Since in fact capital has tended to flow towards more developed countries, particularly the United States, this should not be an issue in any case, but immigration may be more important.

Technology has often been cited as a driver for wage inequality – skill biased technical change has raised the demand for skilled workers relative to unskilled, while the supply has not kept up. Hence wages for skilled workers have increased relative to those for unskilled workers. It is also possible that technological change affects the

wage share, although the effect is theoretically indeterminate, depending on whether capital or labour is being augmented/saved, and the relevant elasticities of substitution. Bentolia and St Paul (2003) and Guscina (2006) both argue that technical change has been biased in favour of capital in the relevant time period.

Institutions, like globalisation, is something of a catch-all term. With respect to the labour market, it is usually used to refer to various aspects of employment law and regulations (e.g. minimum wages, collective bargaining, employment protection, unemployment benefits), as well as social norms regarding fair pay levels. In general, these institutions are considered to alter the relative power of different parties within some kind of implicit or explicit bargaining framework. A stronger bargaining position for either party leads almost tautologically to a larger share of the surplus. These institutions are generally considered to favour lower paid workers, so that their weakening is seen as a cause of rising wage inequality. A more sophisticated argument is that a common shock such as globalisation or technology will have less effect on inequality where institutions are stronger. Similar arguments have been advanced for labour as a whole vs. capital, so that weaker institutions would lower the wage share (e.g. Blanchard and Giavazzi 2003, and Bental and Demougin 2006).

Education has also been cited, although less commonly, as a factor affecting both wage inequality and the wage share. If an increase in the demand for skilled labour tends to increase wage inequality, an increase in the supply of skilled labour should logically reduce it. Daudey and Decrause (2006) argue that an higher supply of education will also increase the labour share by making workers more mobile.

Not surprisingly, these four factors have been commonly cited as causes of both falling wage shares and rising wage inequality. Globalisation, technology, and institutions in particular have simple, appealing theoretical arguments behind them as

well as plausible empirical support in the general direction of change in the world economy. Yet, to repeat, it is precisely because they can explain both trends that they cannot explain why the strength of the two trends are inversely correlated across countries. They remain as potentially significant in explaining the overall average trends. After all, despite the large amount of variation in our sample, all countries experienced a falling wage share, and a majority rising wage inequality. But if we are interested in moving beyond the average trend to explain the differences between countries, we must look for additional factors, or argue that the forces emphasised in the literature do not affect both wage inequality and wage shares in the directions they are supposed to. We now turn to several alternative possibilities.

The degree of *product market competition* may be an important factor. If firms have monopoly power, they will increase their profits by restricting output (and thus labour demand) relative to the competitive level. Conversely, more competitive product markets should increase the wage share (Ripatti and Vilmunen 2001). The effect on wage inequality is less clear, but Lindsey (2009) argues that more competitive markets may undermine other institutions that support income compression. But it is also less clear what the effect of competition on the wage share is if monopoly rents are shared with unions.

Vintage capital is incorporated in a search model by Hornstein, Krusell and Violante (2007), who show that the effect of an increase in the rate of capital-embodied technical progress depends on the level of regulation of the economy. Qualitatively, they find that the more regulated economy should experience a greater fall in the labour share, but their quantitative simulations calibrated to the United States and Europe show practically no difference. An earlier version of the paper (2002) does a better job matching the wage shares but is less successful on other dimensions. This early version

also argues that wage inequality would increase more in the less regulated economy as a result of the same shock, but this was not included in the published version (and again, the quantitative results were small). Although this particular model does not seem capable of accounting for the puzzle, it is an interesting example of the more general point that a common shock may affect different countries in different ways, depending on their institutions.

Capital accumulation could affect the wage share depending on the elasticity of substitution between labour and capital. A value of one for this elasticity (as in a Cobb-Douglas production function) implies constant factor shares, irrespective of the capital-labour ratio. As shown below, if the value is below one, the wage share rises with the capital-labour ratio; above one, and it falls. This conclusion is, however, conditional on accumulation being exogenous with respect to technical progress. If it is instead a response to labour augmenting technical progress, factor shares will remain constant whatever the elasticity of substitution (Arpaia, Perez and Pichelmann 2009). Andersen, Klau & Yndggard (1999), Checchi and Garcia (2005), and Chirinko (2008) all argue that the literature supports an elasticity of less than 1, although Bentolia and Saint-Paul (2003) present a range of estimates on either side. Shifting our attention to wage inequality, capital and skilled labour are generally considered to be complements (Hamermesh 1993), so that capital accumulation should increase the relative demand for, and hence the wages of, skilled labour, all else being equal.

A New Model of Capital-Skill Complementarity

A combination of these two mechanisms – an elasticity of substitution between capital and labour of less than one, and capital skill complementarity – would imply that capital accumulation can potentially increase both wage inequality and the wage share, thus

providing a potential solution to our puzzle. The problem is that insights from a 2 factor setting do not always transfer smoothly when 3 factors are considered. The preferred way of modelling capital-skill complementarity is to aggregate capital K and skilled labour S , and then combine this aggregate with unskilled labour U i.e. $Y = g[U, f(K, S)]$, where f and g are CES functions (Krusell et al 2000). This function displays capital-skill complementarity as long as the elasticity of substitution between K and S in f is less than the elasticity of substitution between U and f in g . Unfortunately, analysing changes in the wage share (the sum of the skilled and unskilled labour shares, or residual from the capital share) is very difficult without detailed numerical simulation (Arpaia, Perez and Pichelmann 2009). The more conventional route of aggregating skilled and unskilled labour first i.e. $Y = g[K, f(U, S)]$ makes the labour share and the skill premium (i.e. wage inequality) simpler to obtain, but since both kinds of labour are identical with respect to capital in the standard formulation, capital-skill complementarity drops out of the model.

We now develop a simple framework that provides both capital-skill complementarity and a simple expression for the wage share. Assume that output is given by a CES production function in capital and aggregate labour,

$$Y = A[aK^\rho + (1-a)L^\rho]^{\frac{1}{\rho}}, \quad (\text{A.1})$$

where $0 < a < 1$ and $\rho < 1$. The marginal product of labour condition $W = Y_L$ yields

$$W = \frac{(1-a)L^{\rho-1}Y}{aK^\rho + (1-a)L^\rho}$$

Combining this with (A.1), we obtain

$$\frac{WL}{Y} = \frac{(1-a)L^\rho}{aK^\rho + (1-a)L^\rho}.$$

Or, writing s_L for the wage share WL/Y and k for the capital-labour ratio K/L ,

$$s_L = \frac{1}{\frac{a}{1-a}k^\rho + 1}. \quad (\text{A.2})$$

Taking the derivative with respect to k ,

$$\frac{ds_L}{dk} = \frac{-a}{1-a} \rho k^{\rho-1} \left/ \left(\frac{a}{1-a} k^\rho + 1 \right)^2 \right. . \quad (\text{A.3})$$

The effect of the capital-labour ratio on the wage share will depend on the sign of ρ .

Since $0 < a < 1$, and $k > 0$, we have $\frac{ds_L}{dk} > 0$ if $\rho < 0$. But since the elasticity of

substitution between capital and labour is $\sigma = \frac{1}{1-\rho}$, this is equivalent to $\sigma < 1$. An

elasticity of substitution of less than one implies that an increase in the capital-labour ratio will increase the wage share.

As mentioned above, this is true for an exogenous increase in k , but not for one that is induced by labour-augmenting technical progress. This can be seen if we write λ_K and λ_L as the parameters for capital- and labour-augmenting technology respectively, and replace K and L in equation (A.1) by their technology augmented versions $\lambda_K K$ and $\lambda_L L$ (which renders the parameter A redundant). Then we must replace k in equations (A.2) and (A.3) above with $(\lambda_K/\lambda_L)k$. It is obvious that if an increase in k is merely proportional to an increase in λ_L , then it does not affect the labour share.

That the effect of k on s_L depends on the value of σ is a standard result for a 2-factor production function. We now show that the result is also applicable to a 3-factor production function with skilled and unskilled labour. Suppose that the labour input is itself a CES aggregate of skilled and unskilled labour (S and U),

$$L = B[bS^\theta + (1-b)U^\theta]^{\frac{1}{\theta}} \quad (\text{A.4})$$

$0 < b < 1$ and $\theta < 1$. The demand for skilled labour relative to unskilled is given by

$$\frac{S}{U} = \left(\frac{b}{1-b} \frac{W_u}{W_s} \right)^{\frac{1}{1-\theta}}, \quad (\text{A.5})$$

where W_s and W_u are the wage rates for skilled and unskilled labour respectively (the ratio of which is the measure of wage inequality). The novelty is to impose $b = b(k)$ with $\frac{db}{dk} > 0$.⁵ Instead of the elasticities of substitution determining capital-skill complementarity, in this formulation it is the share coefficient $b(k)$ that does the work. Then, an increase in the capital-labour ratio will increase the relative demand for skilled labour:

$$\frac{d}{dk} \left(\frac{S}{U} \right) = \frac{1}{b(1-b)(1-\theta)} \frac{S}{U} \frac{db}{dk} > 0. \quad (\text{A.6})$$

Graphically, an increase in the capital-labour ratio will shift outwards the relative demand curve for skilled labour and thus increase its relative wage, as long as the relative supply of skilled labour is not perfectly elastic.

To round out the story, a tendency towards a lower wage share could be represented as a rise in a . From (A.2) we see that

$$\frac{ds_L}{da} = \frac{-k^\rho}{(1-a)^2} \left/ \left(\frac{a}{1-a} k^\rho + 1 \right)^2 \right. < 0. \quad (\text{A.7})$$

Say that all countries have a common technology, which has changed over time in some way that implies a lower wage share. Simultaneously, different countries are accumulating capital at different rates. Those countries that, for whatever reason, experienced a more rapid accumulation of capital (for a given rate of labour augmenting

⁵ For tractability, it is easiest to assume that k is exogenous e.g. in a Solow-Swan steady state. If this is not the case, then a change in b , which most likely alters the equilibrium value of L , will have feedback effects on k . However, it seems plausible to assume that an initial increase in k would not cause feedback effects that result in k falling below its starting value, since the only feedback mechanism is the change in b resulting from the initial increase in k .

technical progress), would see their capital-labour ratio rise, which would increase both the wage share according to (A.3) and the relative demand for skilled labour (and hence wage inequality) according to (A.6). Thus this country could end up with increasing wage inequality but a fairly stable wage share (as in the United States), while those countries with lower capital accumulation would not experience a rise in wage inequality, but would see their wage shares fall by more (as in Japan). Admittedly, hypothetical changes in the parameter a are a somewhat arbitrary method of formalisation, but this device is only employed to generate a common trend towards a lower wage share. The differences between countries, which are our main interest, are entirely driven by the effects of capital accumulation in this exercise.

Bottom 99% Wage Shares

The wage share may include significant incomes that should more properly be classed separately from the income of the mass of workers. We may very broadly say that the English-speaking countries – Australia, New Zealand, the United Kingdom and the United States – have seen greater rises in wage inequality and smaller falls in the wage share when compared with Europe (except Denmark) and Japan. It is well known that these are also the countries where the trend towards increasing CEO pay has been the strongest (Gabaix and Landier 2008). More generally, many refer to a distinct Anglo-Saxon form of capitalism, with features such as a reliance on financial markets over banking,⁶ more dispersed shareholding (Morck 2009), and more lawyers (Karabel 2010 Fig. 11). If the incomes of the top earners in this system are viewed as being substantially rents extracted from the capital share (a potentially controversial assumption), we may have a partial explanation of our puzzle. In marginal product

⁶ http://lexicon.ft.com/term.asp?t=Anglo_Saxon-capitalism

terms there should have been a shift from labour to capital everywhere, but in the English-speaking countries a large part of this income has been captured by highly paid managers, financiers and lawyers.

One way of measuring the magnitude of this effect is with a bottom 99% wage share, as is done by Glyn (2009) for the United States. Subtracting the top 1% of wage incomes from the wage share gives a more accurate picture of the share of the mass of the workforce in the national product. One would ideally write (omitting country and time subscripts) the bottom 99% wage share as

$$s_L^{99} = s_L(1 - top1_L), \quad (A.8)$$

where $top1_L$ is the top 1% share of labour incomes and s_L is the wage share. For example, if the wage share is 60% of GDP, and the top 1% of earners have a 10% share of wage incomes, then the bottom 99% wage share is $0.6(1-0.1)$, or 54%.

Unfortunately, data on $top1_L$ is not available for all countries in our sample. A more widely available statistic is the top 1% share in total personal income ($top1_Y$), which is taken from Leigh (2007). Using this, we construct a proxy

$$s_L'^{99*} = s_L - c.top1_Y \quad (A.9)$$

where c is a constant chosen so that the arithmetic mean of $c.top1_Y$ is equal to the arithmetic mean of $s_L.top1_L$ (i.e. $s_L'^{99*} = s_L^{99}$ in means) for the United States from 1970-2004, where both measures are available (see appendix for $top1_L$). In other words, we simply attribute a constant share of the top 1% of personal incomes to labour, and use this as a proxy for the share of the top 1% of labour incomes in GDP, picking the constant so that the average value of $s_L'^{99*}$ from equation (A.9) is equal to the average value of the more accurate (A.8) for the US. The value of this constant, c , is approximately 0.46.

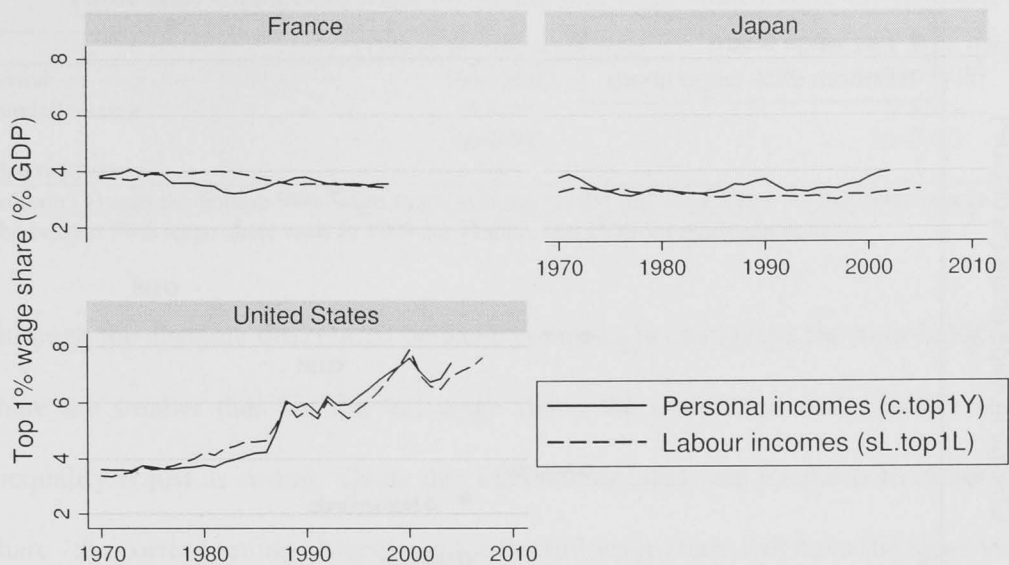


Figure A.4: Top 1% wage shares estimated from top personal and labour incomes data.

To check that this proxy is reasonably robust, we compare $c.top1_Y$ with the values of $s_L.top1_L$ for the other countries where it is available. For Japan, Moriguchi (2008: Table 2) gives $top1_L$. For France, Piketty (2003: Figure 3) shows that $top1_L$ has been around 6% since the 1970s. Figure A.4 shows that the differences between $c.top1_Y$ and $s_L.top1_L$ (and hence between s_L^{99*} and s_L^{99}) for each country are small compared to the differences between countries using either measure. The correlation between the two measures is 0.96 based on 97 observations.

It might be objected that this is a purely mechanical exercise. Since wage shares have fallen the least where wage inequality has risen the most, subtracting any proxy for wage inequality from the wage share can hardly help but reduce the differences between countries in how the wage share has changed.

In answer to this objection, two points may be made. Firstly, the measure used

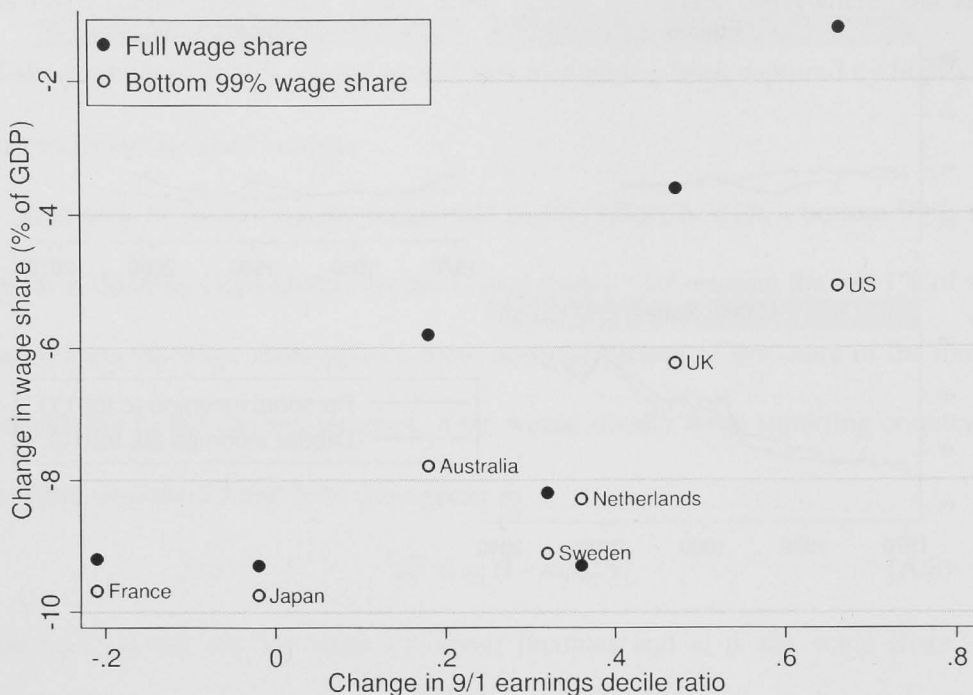


Figure A.5: Changes in wage inequality and bottom 99% wage shares, 1980-2000.

here for wage inequality only goes up to the 90th percentile of earnings, while the correction to the wage share uses the 99th and above. Empirically, wage incomes above the 99th percentile have behaved very differently from those between the 90th and 95th and even the 95th-99th percentiles (Piketty and Saez 2007:159,162). Theoretically, it seems unlikely that the rent-seeking argument proposed above would apply as strongly at the 90th percentile. Secondly, the argument is not just qualitative but quantitative: even if the correction is likely to go in the ‘right’ way by construction, there is still the question of whether the magnitude of the correction is enough to eliminate the pattern shown in Figure A.3.

The answer to this question appears to be ‘no’. A more systematic treatment is given in the next chapter, but for now note that the subtraction of the top 1% of incomes from the wage share can explain at most 5 percentage points of the difference between the United States and France or Japan. This is shown visually in Figure A.5 where,

Table A.3: Changes in wage inequality and wage shares, rank correlations.

	(1) Bottom 99% wage share	(2) Full wage share
Period	1980-2000	1980-2000
Kendall's tau-a	0.72** (p=0.04)	0.62* (p=0.07)
Observations	7	7

Column (1) uses the bottom 99% wage share, column (2) the full wage share for the same sample. The bottom 99% wage share ends in 1998 for France, and 1999 for the Netherlands.

although the absolute differences between countries in changes in the bottom 99% wage share are smaller than for the full wage share, the correlation with changes in wage inequality is just as strong. (Note that the country labels are for the bottom 99% wage share –the corresponding observation for the full wage share will have the same value of the 9/1 decile ratio i.e. be vertically above or below.) Indeed, when we calculate the rank correlation between the changes in this bottom 99% wage share and wage inequality, Table A.3 shows that it is actually slightly higher (and more significant, although a sample of 7 is really too small to appeal to asymptotics) than the correlation using the full wage share, when this is calculated using the same restricted sample.

To recap, we have considered many possible determinants of wage inequality and wage shares, and the extent to which they would predict a correlation between higher wage shares and higher wage inequality. The most popular explanations – globalisation, technology, and institutions – do not seem particularly promising in this regard. Of the remainder, capital accumulation and the behaviour of top labour incomes promise at least a theoretically consistent explanation. Their empirical relevance remains to be considered.

CHAPTER A4. PANEL REGRESSIONS

We have considered a large number of factors which potentially affect wage inequality and wage shares, but what is their empirical significance? To explore this question, panel regressions are conducted with both the wage share and wage inequality as dependent variables. The aim is to find whether a combination of variables from Chapter A3 can provide a theoretically plausible accounting explanation of the pattern in Figure A.3: that wage inequality has risen the most in those countries where wage shares have fallen the least.⁷

It is evident that any variable which is practically significant in both regressions, but with opposite signs (i.e. which predicts that wage inequality should be higher when the wage share is lower, and vice-versa) cannot be part of such an explanation. We are therefore searching for variables which have the same sign in both regressions, or alternatively, variables which are significant in one regression, but not both. For example, a higher capital-labour ratio may be correlated with higher wage shares and higher inequality. Or, education might be an important determinant of wage inequality but have a negligible effect on the wage share. Of course, having variables with the right signs is a necessary, but not sufficient condition. The size of the coefficients and the amount of variation in the explanatory variables must also be of sufficient magnitude to explain a significant fraction of the puzzle.

Two measures are employed to test this overall sufficiency. Firstly, the seemingly

⁷ The results should be seen as analagous to a growth accounting or inequality decomposition exercise, not as an attempt to identify the exogenous 'deep determinants' of each variable. No attempt is made to advance beyond the existing literature in estimation technique or identification strategy. The studies listed below in Table A.4 rely almost entirely on OLS.

unrelated regression framework is used to test for correlation between the residuals in the wage inequality and wage share regressions. A positive correlation would be an indication that, even after all of the explanatory variables are accounted for, wage inequality is still unexpectedly high when the wage share is unexpectedly high. Conversely, a lack of correlation between the residuals would indicate that there is no systematic relationship between the unexplained components of wage shares and wage inequality, i.e. that the set of explanatory variables *is* capable of providing a solution to our puzzle. Secondly, the residual *changes* in each variable between 1980 and 2000 are compared with the raw changes from Figures A.3 and A.4, to test more directly how well the estimated models can account for the pattern we are trying to explain. This measure has the advantage of using the absolute size of the residuals, as well as the strength of the correlation between them. These exercises are performed using both the full and bottom 99% wage shares as dependent variables, and with a variety of alternate specifications.

Variable Selection

Selection of variables is a difficult task, given the number of competing explanations and the large set of potential proxies for each. Tables A.4.a and .b summarise recent studies which employ panel regression at the country level to explain wage inequality and wage shares respectively. The literature is quite small, particularly regarding wage inequality, and there is not much of a consensus on the appropriate variables or the sign of their effects, let alone their size.

Variables were selected on the basis of a convincing theoretical rationale, empirical support from the listed studies, and data availability. The included variables were collective bargaining coverage, the capital-labour ratio, the fraction of the working

Table A.4.a: Summary of wage inequality panel regression literature.

	Burniaux, Padrini & Brandt (2006)	Checchi & Garcia (2005)	Checchi & Garcia (2008)
Output gap			
Unemployment benefit	0	-	0
Union density	-	-	0
Minimum wage		-	0
Tax wedge	0		+
K/L	0	-	
Other	Education (0), Output gap (-) Social expenditure (-) Labour market spending (0)		UB.EPL (0) Wage coordination (0)

Table A.4.b: Summary of wage share panel regression literature.

	Bentoilia & St Paul (2003)	Checchi & Garcia (2005)	Checchi & Garcia (2008)	Daudey & Decreuse (2006)	Ellis & Smith (2007)	Guscina (2006)	Jaumotte & Tytell (2008)
Oil price	0	-			0		
RER					-		-
Trade/GDP					0	-	
EPL					-	0	0
PMR					0		0
UB		+/0	+				-
Union density		0	0	+			0
Min. wage		0	0				
Tax wedge			0				-
K/L		+					0
K/Y	-			-			
Education		-		+			
	Labour conflict (-/0)		UB.EPL (-) Wage coord. (0)	Unempl -oyment. rate (-)	GDP growth (-) t.EPL (+) t.PMR (-)	Y/L (0)	Offshoring (-) Immigration (-) ICT K (-)
Other	Employment growth (-) TFP (-)						

All regressions use year and country fixed effects, except Ellis & Smith who use a time trend, and Guscina who uses first differences, instead of year FE.

+, -, 0 indicate statistically significant positive and negative, and statistically insignificant results. /0 indicates significance at 10% but not 5% level.

RER=real exchange rate, EPL=employment protection legislation, PMR=product market regulation, UB=unemployment benefit, TFP=total factor productivity, ICT=information & communication technology.

Education is measured by Burniaux et al and Checchi & Garcia as years of education, Daudey & Decreuse as % of workforce with a tertiary education.

Ellis & Smith's trade/GDP variable only includes trade with developing countries.

Jaumotte & Tytell use import and export prices separately instead of the real exchange rate.

Harrison (2002) and Jayadev (2007) were not included because they used a much larger sample consisting mainly of developing countries, as well as a different set of explanatory variables.

age population with a tertiary education, GDP growth, and the real exchange rate. More detail on variable definitions, data sources, robustness checks etc. is given in the Data Appendix following Chapter A5.

Dealing first with some of the obvious variables that were not included, *technology* is not directly measured, both because of the lack of consensus in Tables A.4.a and .b as to how it is best measured, and also because of the complications regarding labour- and capital-specific change discussed in the previous chapter. Any technological developments that are common across countries (as in the simplest version of the globalisation story) should be controlled for by the year fixed effects.

Product market regulation is insignificant in all three wage share studies where it is used. As for other measures of product market competition, Przybyla and Roma (2005:5-6) conclude that ‘amongst the proxies used mark-up, measured as the inverse of the labour income share, performs best.’ This is rather unhelpful when one is seeking to explain the wage share!

The *capital-output ratio* is linked to too many different explanations to be informative: ‘as long as labor is paid its marginal product, there should be a one-for-one relationship between the labor share and the capital-output ratio . . . Any change in the labor share which shows up as a deviation from that relationship must arise from a shift in labor demand which is not due to real wages, capital accumulation, or labor-augmenting technical progress’ (Bentoilia & St Paul 2003).

Also not included is any indication of the sectoral makeup of each economy. Azmat, Manning and van Reenen (2007) show that privatization has reduced the wage share in network industries, but admit that this is only a small part of the total change, speculating that the shift out of manufacturing may be important. Empirically, however, Lawless and Whelan (2007) and Glyn (2009) have found that the fall in the

wage share is largely a within sector phenomenon, rather than being driven by composition effects. And theoretically, like the capital-output ratio, changes in sectoral composition could be the result of too many different forces to be really informative. A decline in labour intensive manufacturing, for example, could equally well be the result of competition from lower wage countries, or technological progress.

Turning now to the included variables, the real exchange rate (2005=1, where a higher value indicates appreciation) is used to measure the effects of *globalisation*. If developed country exports are relatively intensive in capital and/or skilled labour compared to imports, a real appreciation would tend to increase wage inequality and/or decrease the wage share. This measure of the relative price of imports and exports is used in preference to a measure of quantity such as trade/GDP, since this variable was insignificant in Ellis and Smith (2007) when the real exchange rate is included as a control. Trade also gets very little support in Gordon and Dew-Becker's (2008) and Machin's (2008) surveys of the wage inequality literature. Immigration was not considered, since its effects should be adequately captured by the capital-labour ratio and the level of education.

Institutions were measured by collective bargaining coverage as a fraction of the workforce, the only variable in this paper that does not appear in Tables A.4.a and .b. As argued by Booth (1995:5) and Checchi and Visser (2009), this variable gives a better indication of the strength of the institutional wage floor than union membership. In countries such as Australia and France, collectively bargained wages and conditions cover a majority of the workforce despite low union membership. As well as being included in levels, coverage is also interacted with a time trend, to capture the possibility that a common shock might affect countries differently depending on their institutions. Our theoretical priors would indicate that stronger institutions should be

correlated with lower wage inequality and a higher wage share. The minimum wage is another potential measure, but it was not available for several of the countries in our already small sample, as well as being highly correlated with the coverage variable. It is, however, used in an alternate specification later in this chapter. Unemployment benefits were not used since the empirical results in table 4.A are inconsistent, and they have received less attention in the literature generally.

Education is measured by the fraction of the population aged 25-64 with a tertiary education i.e. the relative supply of skilled labour. Again, our prior is for education to lower wage inequality, and possibly increase the wage share.

Capital accumulation is measured by the capital-labour ratio. Theoretically, when used as an explanatory variable for the wage share, it should be adjusted for productivity. However, given that separate estimates for capital- and labour-augmenting productivity are not generally available and are very complicated to calculate (e.g. Ripatti and Vilmunen 2001), the only practical course would be to assume some common trend in productivity growth for all countries, as is done in Kehoe and Prescott (2001). And this is redundant as long as the regression uses time controls: if we deflate the capital-labour ratio k (omitting time and country subscripts) by a time factor $\exp(at)$ (where a is the growth rate of the appropriate productivity variable) and then take the natural log, we are left with $\ln(k)-at$. The second term would clearly be swept out by a linear time trend, let alone year fixed effects. According to our theory, capital accumulation should cause higher wage inequality and a higher wage share.

Top labour incomes are controlled for using the bottom 99% wage share calculated in the previous chapter. (Strictly speaking, this is a modification to the dependent variable, not an explanatory variable per se.)

Table A.5: Descriptive statistics for regression data.

Variable	Observations	Mean	Std. dev.	Minimum	Maximum
d91	290	2.93	0.64	1.95	4.86
Share	290	61.3	5.16	45.0	76.4
Top1	205	3.52	1.24	1.65	7.6
Coverage	290	0.63	0.27	0.13	0.97
Education	290	0.21	0.06	0.07	0.39
RER	290	1.03	0.14	0.73	1.52
ln(K/L)	290	11.9	0.26	11.2	12.4
GDP growth	290	0.025	0.019	-0.067	0.070

d91 = 9/1 earnings decile ratio, Share = wage share. Top1 = top1_y. RER = real exchange rate

Finally, GDP growth is included as a cyclical control: it is generally accepted that the wage share is anticyclical, so growth should enter with a negative sign.

The descriptive statistics are given below in Table A.5. These are for the observations used in the regressions only, and do not include the inequality and share data for Korea used in chapter A2, or data for other countries in years where some of the variables are not available. It does, however, include some observations generated by linear interpolation (see the Data Appendix).

The correlation matrix is given in Table A.6. Of note are the strong negative correlations between collective bargaining coverage (coverage) and wage inequality (d91), and between education and the wage share. The first is in accord with our priors, but the second is very surprising. Within the explanatory variables, the (log) capital-labour ratio is strongly positively correlated with education. Finally, it is interesting to note that wage shares and wage inequality are positively correlated even in levels, although weakly.

Table A.6: Correlation matrix for regression data.

	d91	Share	Coverage	Education	REER	ln(K/L)
d91	1					
Share	0.24	1				
Coverage	-0.65	-0.26	1			
Education	0.11	-0.53	-0.34	1		
RER	-0.10	0.31	0.05	-0.15	1	
ln(K/L)	0.23	-0.19	-0.04	0.58	0.02	1
GDP growth	0.14	-0.11	-0.09	0.05	-0.18	0.03

Baseline Results

We now turn to the regressions themselves. As emphasised above, because of potential issues with data quality and endogeneity, these should be seen as a cautious accounting exercise: how much of the historical variation in wage inequality and wage shares can be accounted for by variables that have been theoretically and empirically identified as potential explanators? The seemingly unrelated regression (SUR) estimator is used, with year and country fixed effects to sweep out unobserved common shocks and heterogeneity between countries. The results for the full sample of 290 observations are shown below in Table A.7.a.

In column (1), we first estimate a model with year and country fixed effects as the only explanatory variables. This provides a baseline for the residual correlation, in a way that will become clearer below. For now, simply note the reasonably high and strongly significant positive correlation between the residuals, indicating that wage inequality tends to be high when wage shares are high (after accounting for changes that affect all countries in a given year, and unchanging country level effects).

Column (2) shows the model with the full set of explanatory variables. At first glance these variables seem to do a good job of reducing the residual correlation, which falls from 0.46 to 0.10, and is only marginally significant. Perhaps, then, the mystery is no longer a mystery. But looking more closely at the regression coefficients, we find that we have replaced one mystery by another. For wage inequality, we find that education, and the interaction of collective bargaining coverage with time, are both negative and significant. This is in accord with our priors. But turning to the wage share, we find that, although it is countercyclical as expected, it has a significant negative correlation with both collective bargaining and education! Education seems particularly important since it is significant with the same sign in both equations, one of

Table A.7.a: Seemingly Unrelated Regression, 1975-2007.

Dependent variable:	(1) FE only		(2) Full model		(3) - Education	
	d91	Share	d91	Share	d91	Share
Coverage			-0.018 (0.16)	-3.35** (2.12)	-0.025 (0.16)	-3.43* (1.77)
Coverage.time			-0.0252*** (8.17)	-0.046 (1.15)	-0.0277*** (6.19)	-0.078 (1.38)
Education			-6.24*** (18.0)	-62.4*** (12.1)		
RER			-0.018 (0.31)	-0.42 (0.50)	-0.052 (0.63)	0.27 (0.26)
ln(K/L)			-0.19 (1.61)	1.8 (1.03)	-0.740*** (4.45)	-3.67* (1.77)
GDP growth			0.53 (1.37)	-44.3*** (7.76)	1.38** (2.48)	-35.8*** (5.15)
Observations	290		290		290	
Countries	10		10		10	
Residual correlation	0.46*** (p=0.00)		0.10* (p=0.08)		0.48*** (p=0.00)	

All regressions include country & year fixed effects.

***/**/* indicate significance at 1/5/10% level using a two-tailed test.

Brackets contain z-statistics for regression coefficients, and p-values for Breusch-Pagan tests of residual correlation.

the necessary conditions identified above. Yet by what plausible mechanism would an increase in the proportion of the population with a tertiary education reduce the wage share? If we drop this variable, however, as is done in column (3), all the other variables put together do nothing to reduce the residual correlation. In fact, at 0.48, it is slightly higher than in the model with no fixed effects!

While suggestive, the residual correlation is not a perfect measure of the puzzle we are trying to explain. It says nothing about the size of the residuals relative to the raw changes in wage inequality and wage shares. Furthermore, there is a theoretical possibility that the residual correlation could be extremely strong at the annual frequency used to estimate the regressions, but nonexistent over longer periods (although this is the reverse of what we would expect given the results in Table A.2).

To deal with these issues, we create a regression version of Figure A.3 based on the changes in the residuals from the estimated equations. Note that we can always express any observed value of wage inequality or the wage share for a given country

and year (y_{it}) as the sum of the value predicted by a particular model (\hat{y}_{it}) and the residual from that model (\hat{u}_{it}) i.e.

$$y_{it} = \hat{y}_{it} + \hat{u}_{it} .$$

Therefore, omitting time subscripts, we can write the change from any year $t = T$ to any other year $t = T + S$ as

$$\Delta y_i = \Delta \hat{y}_i + \Delta \hat{u}_i . \quad (\text{A.10})$$

Now, suppose that the model in question is the fixed effects only model from column (1) of Table A.7.a i.e.

$$\hat{y}_{it} = \hat{a}_i + \hat{d}_t ,$$

where \hat{a}_i is the estimated country FE and \hat{d}_t the estimated year FE. Then

$$\Delta \hat{y}_i = \Delta \hat{d}$$

and, using (A.10),

$$\Delta \hat{u}_i = \Delta y_i - \Delta \hat{d} . \quad (\text{A.11})$$

The change in the residual is simply the change in the dependent variable minus the change in the year fixed effect, which does not vary across countries. In other words, by plotting the change in the residual from the FE only model, we are effectively recreating Figure A.3, except that both scales have been remeaned. Figure A.6 is indeed identical except for this change in scale and the omission of Korea.

With the FE model as a baseline, we then perform the same exercise using the models from columns (2) and (3) of Table A.7.a, which allows the predicted value \hat{y}_{it} to contain a richer set of explanatory variables. When these are superimposed on Figure A.6, two results stand out immediately. Firstly, the residual changes are compressed more (relative to the FE only model) in the horizontal axis, indicating that both models

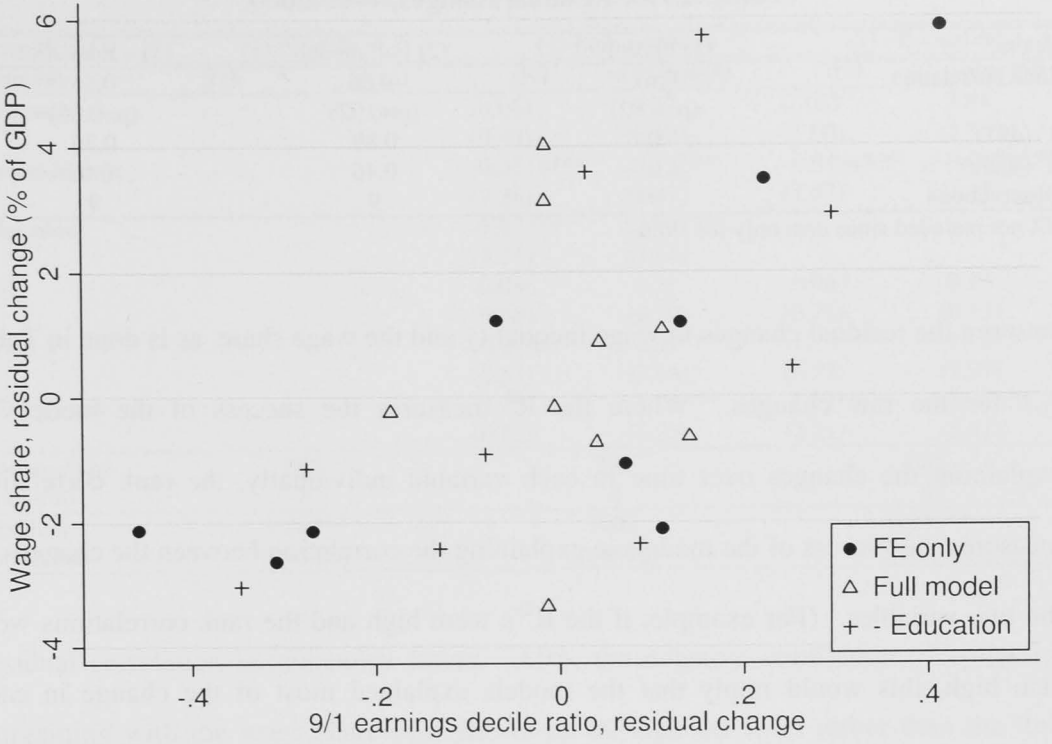


Figure A.6: Residual changes in wage inequality and the wage share, 1980-2000.

are better at explaining the changes in wage inequality than the changes in the wage share. Secondly, the education variable is absolutely crucial to the performance of the model, as shown by the much greater spread in the residual changes when it is dropped.

As well as this visual comparison, we calculate an R^2 -like measure of the fraction of variance in the residual changes explained by the different models. Since, for a given T and S , equation (A.11) implies that $Var(\Delta\hat{u}_i) = Var(\Delta y_i)$ for the FE only model, we may write

$$R^2 = 1 - \frac{Var(\Delta\hat{u}_i)}{Var(\Delta y_i)} \quad (\text{A.12})$$

for whichever model and dependent variable we are interested in. (This will equal zero for the FE only model.) Table A.7.b shows these values calculated for the period 1980-2000 (i.e. $T=1980$ and $S=20$) for both wage inequality and wage shares, with and without education as an explanatory variable. Also given is the rank correlation

Table A.7.b: Residual changes, 1980-2000.

Model	(1) FE only	(2) Full model	(3) – Education
Rank correlation	0.67** (p=0.02)	-0.06 (p=0.92)	0.56** (p=0.05)
R ² (d91)	0	0.89	0.36
R ² (share)	0	0.46	-0.08
Observations	9	9	9

NZ not included since data only for 1986-.

between the residual changes in wage inequality and the wage share, as is done in Table A.1 for the raw changes. Where the R^2 measures the success of the models in explaining the changes over time in each variable individually, the rank correlation measures the success of the models in explaining the correlation between the changes in the two variables. (For example, if the R^2 's were high and the rank correlations were also high, this would imply that the models explained most of the change in each variable, but that the residual changes were still highly correlated.)

These results confirm the visual impression from Figure A.6. When the education variable is included, the model can explain nearly 90% of the variance of the changes in wage inequality, and nearly half of the variance of the changes in the wage share. Furthermore, the positive correlation between the changes completely disappears – our puzzle has been ‘explained’. Yet when we drop education from the model, it can explain little more than a third of the variance in the changes in wage inequality, none of the variance of the changes in the wage share,⁸ and the correlation of the residual changes is nearly as strong as in the FE only model (i.e. in the raw inequality/shares data).

We now repeat these exercises with the bottom 99% wage share (share99) replacing the wage share. The notable differences in Table A.8.a compared to A.7.a are that the capital-labour ratio is now significant and negative in both regressions, and the

⁸ The fraction of variance explained can be negative, unlike the R^2 for an OLS regression, because the model used to generate the residual changes $\Delta\hat{u}$, is not fit to maximise (A.12).

Table A.8.a: SUR, bottom 99% wage share.

Dependent variable:	(1) FE only		(2) Full model		(3) - Education	
	d91	Share	d91	Share99	d91	Share99
Coverage			-0.051 (0.40)	1.77 (0.98)	0.163 (1.09)	2.91 (1.59)
Coverage.time			-0.0319*** (7.36)	-0.153** (2.47)	-0.0404*** (7.87)	-0.0199*** (3.17)
Education			-5.87*** (9.71)	-31.4*** (3.64)		
RER			-0.046 (0.68)	0.21 (0.22)	-0.061 (0.76)	0.13 (0.13)
ln(K/L)			-0.0434** (2.53)	-8.97*** (3.66)	-1.23*** (6.77)	-13.2*** (5.97)
GDP growth			0.25 (0.52)	-42.0*** (6.23)	1.23** (2.21)	-36.8*** (5.41)
Observations	205		205		205	
Countries	8		8		8	
Residual correlation	0.26*** (p=0.00)		0.09 (p=0.18)		0.21*** (p=0.00)	

residual correlation is somewhat lower. Also, the negative correlation of collective bargaining with the wage share now shows up through the level rather than the time interaction. Otherwise, the results are very similar, particularly with regards to the effect of the education variable.

Turning now to the residual changes, we see that the basic pattern of Table A.7.b is repeated in Table A.8.b, except that the rank correlation of the residual changes does not increase when education is dropped from the model. However, this is not because the model without education is performing better in this case. Rather, it is because it is doing such an abysmal job of explaining the bottom 99% wage share (as shown by the strongly negative R^2).

Table A.8.b: Residual changes 1980-2000, bottom 99% wage share.

Model	(1) FE only	(2) Full model	(3) - Education
Rank correlation	0.81**	0.14	0.14
p-value	0.02	0.76	0.76
R^2 (d91)	0	0.85	0.57
R^2 (share99)	0	-0.16	-0.55
Observations	7	7	7

Changes for France and the Netherlands are from 1980-98 and 1980-99 respectively.

Table A.9.a: SUR, restricted sample.

Dependent variable:	(1) FE only		(2) Full model		(3) – Education	
	d91	Share	d91	Share	d91	Share
Coverage			-0.051 (0.40)	0.69 (0.37)	0.163 (1.09)	2.51 (1.29)
Coverage.time			-0.0319*** (7.36)	-0.269*** (4.24)	-0.0404*** (7.87)	-0.341** (5.11)
Education			-5.87*** (9.71)	-50.1*** (5.67)		
RER			-0.046 (0.68)	-0.012 (1.19)	-0.061 (0.76)	-1.29 (1.23)
ln(K/L)			-0.434** (2.53)	-7.13*** (2.84)	-1.23*** (6.77)	-13.9*** (5.89)
GDP growth			0.25 (0.52)	-40.6*** (5.87)	1.23** (2.21)	-32.2*** (4.43)
Observations	205		205		205	
Countries	8		8		8	
Residual correlation	0.46*** (p=0.00)		0.18*** (p=0.01)		0.35*** (0.00)	

Since the bottom 99% wage share is estimated on a more restricted sample of 205 observations, we must check if these differences are a result of the adjustment to the wage share or just the smaller sample. Therefore, we repeat the analysis again using the full wage share on the restricted sample. The results are shown in Tables A.9.a & b.

The residual correlation is similar to Table A.7.a (the full sample) in column (1), higher in (2) and lower in (3). Compared to the values in Table A.8.a where the bottom 99% wage share was used, the correlations are higher across the board. In this sense one may say that the adjustment goes some way towards explaining the puzzle. The significance of the capital-labour ratio seems to be an artefact of the restricted sample, rather than the adjustment to the wage share, as does the shift in significance from the level of collective bargaining to the time interaction. The residual changes below are fairly similar to those in the full sample, although the rank correlation in (1) is slightly higher, again indicating that the change in the sample rather than the adjustment to the wage share is the cause.

Table A.9.b: Residual changes, 1980-2000, restricted sample.

Model	(1) FE only	(2) Full model	(3) – Education
Rank correlation	0.81**	0.14	0.52
p-value	0.02	0.76	0.13
R ² (d91)	0	0.85	0.57
R ² (share)	0	0.44	0.13
Observations	7	7	7

Taking the results as a whole, it is clear that we have much better explanations for changes in wage inequality than for changes in the wage share. This is true both statistically (in the b tables, the R-squareds for the residual changes are much higher for wage inequality than for the wage share) and in terms of economic intuition. It makes perfect sense that a greater supply of educated labour, and stronger labour market institutions, should act to contain rises in wage inequality (although it is interesting that the effect of bargaining works through the time interaction, indicating that it is not the weakening of institutions *per se* that drives rising wage inequality, but rather than stronger institutions tend to check what would otherwise be a rise in inequality over time). It makes much less sense that the same factors should result in a lower wage share. If we were willing to accept these as causal relationships, we might indeed say that we had an explanation for our puzzle, since the residual correlation, both in levels and changes, becomes much smaller and less significant in our full models when compared with the FE only baseline. Yet if we reject the correlation as spurious and economically implausible, we are left with little explanatory power over the wage share, except the fact that it is anticyclical (which is of limited use in explaining long run trends). The use of the bottom 99% wage share marginally reduces the correlation in the level of the residuals, but does not have the same effect on the residual changes, which are the closest measure of our puzzle.

Finally, we consider some further variations on the specifications, including a parsimonious model with robust, clustered standard errors, a growth-style regression

using 5 year averages in first differences and levels, and alternative measures of education and labour market institutions. While some of the results using 5 year averages are weaker (as might be expected given the results in Table A.2), none of these analyses challenge the main points listed above. Indeed, the alternative education measure compounds the mystery by being insignificant with respect to both wage inequality and shares.

Alternative specifications

We now consider some alternative specifications to the SUR used above. Table 11.8 shows equations estimated on the same data by OLS with robust, clustered standard errors, which are used to create a parsimonious version of each equation. We see that these results are practically the same as those above, both in terms of which variables are significant, and the residual changes of the various models. (Because we estimate each equation individually rather than using SUR, we do not have results for the Breusch-Pagan test of residual correlation.) All specifications use the same time periods as above, data permitting (see Appendix Table 1 at the end of the Data Appendix).

Table A.10.a: Parsimonious regressions with robust standard errors.

Dependent variable:	(1) FE only		(2) Parsimonious model		(3) – Education	
	d91	Share	d91	Share	d91	Share
Coverage						
Coverage.time			-0.0234*** (3.97)	-0.0131* (1.93)	-0.0213 (1.34)	-0.12 (0.70)
Education			-6.53*** (12.53)	-61.7*** (4.84)		
RER						
ln(K/L)						
GDP growth				-42.6*** (4.95)		-30.3** (2.35)
Observations	290		290		290	
Countries	10		10		10	

Robust t-statistics clustered by country. Significance levels based on 9 degrees of freedom (# clusters – 1). F-tests for exclusions in parsimonious model have p-values 0.51, 0.79 for d91 and share respectively.

Table A.10.b: Residual changes, 1980-2000, parsimonious model.

Model	(1) FE only	(2) Parsimonious model	(3) – Education
Rank correlation	0.67** (p=0.02)	-0.22 (p=0.47)	0.28 (p=0.35)
R ² inequality	0	0.90	0.14
R ² share	0	0.42	-0.02
Observations	9	9	9

Next, we take a very different approach, taking 5 year averages of the data and running an SUR on their first differences, along with the levels of each dependent variable (to capture any reversion to the mean) and collective bargaining (to correspond to the time interaction in the previous models).

Again, the main conclusions are unchanged. The residual correlation, however, is low even in the FE only model, as can be seen in Table A.11. (The residual changes are not meaningful here because the dependent variables are in first differences, not levels.) The level of both dependent variables is statistically insignificant, indicating that disequilibrium effects do not seem to be important.

Table A.11: SUR with first differences, 5 year averages.

Dependent variable:	(1) FE only		(2) Full model		(3) - Education	
	d91	Share	d91	Share	d91	Share
Dep. var.			-0.24	-0.100	-0.006	-0.121*
(level)			(0.92)	(1.45)	(0.19)	(1.82)
Coverage			-0.34	-1.5	-0.480*	-1.9
			(1.49)	(0.38)	(1.74)	(0.47)
Coverage			-0.189***	-0.58	-0.137*	-0.55
(level)			(2.77)	(0.58)	(1.67)	(0.54)
Education			-5.88***	-33.5		
			(4.13)	(1.60)		
Real exchange			0.040	0.2	1.2	0.5
			(0.29)	(0.07)	(0.73)	(0.23)
ln(K/L)			-0.12	2.6	-0.34	1.9
			(0.33)	(0.44)	(0.81)	(0.32)
GDP growth			0.74	-58.1***	0.81	-57.0
			(0.73)	(0.00)	(0.65)	(3.34)
Observations			44		44	
Countries			10		10	
Residual correlation	0.18 (p=0.23)		0.08 (p=0.60)		0.14 (p=0.36)	

Finally, we consider alternative measures of educational attainment and labour market institutions. Given the surprising correlation of the IIASA measure of higher education with lower wage shares, it seems desirable to check the robustness of this result by using an alternate data source from Barro and Lee (2000). The interpretation of this variable is exactly the same: the fraction of the working age population with at least some tertiary education. For the 260 observations where both series are available, the correlation is 0.69, indicating that, while the series are not wildly divergent, there is certainly room for different results. The correlation with the level of the wage share is -0.50 (249 observations), which is similar to the -0.53 for the original measure. However, as shown in Table A.12, the Barro & Lee education variable is not significantly correlated with either wage inequality or the wage share once the other explanatory variables and fixed effects are added. This is certainly reassuring in terms of the wage share, but disappointing with regards to wage inequality (since it seems perfectly reasonable that a greater supply of educated labour should reduce wage inequality). By way of compensation, the capital-labour ratio becomes significantly negative in both regressions (contradicting the theory proposed in chapter A3!). It is also notable that the residual correlation remains very high and significant, indicating a large unexplained component to the correlation between higher wage inequality and higher wage shares. Since the Barro & Lee measure is only available up to the year 2000, restricting the size of the sample to 235 observations, we also run the regression with the IIASA education measure on the same sample. Table A.12.a confirms that the significance of the education variable and the overall explanatory power of the model depends on the particular education measure used and not the smaller sample. The significance of the other variables, however, seems to be partly an artefact of the sample.

Table A.12.a: SUR, Barro & Lee education measure.

Dependent variable:	(1) FE only		(2) Barro & Lee		(3) IIASA	
	d91	Share	d91	Share	d91	Share
Coverage			0.02 (0.10)	-2.1 (0.76)	0.01 (0.09)	-2.64 (1.35)
Coverage.time			-0.0351*** (4.44)	-0.196* (1.88)	-0.0325*** (7.43)	-0.156** (2.39)
Education			0.0034 (0.65)	0.015 (0.21)	-6.55*** (10.8)	-57.2*** (6.34)
RER			-0.008 (0.11)	-0.23 (0.23)	-0.032 (0.52)	-0.39 (0.43)
ln(K/L)			-1.06*** (6.34)	-9.85*** (4.47)	-0.294* (1.95)	-3.03 (1.35)
GDP growth			0.870* (1.84)	-44.4*** (7.11)	0.32 (0.83)	-49.3*** (8.50)
Observations	235		235		235	
Countries	10		10		10	
Residual correlation	0.39*** (p=0.00)		0.32*** (p=0.00)		0.13** (p=0.04)	

Table A.12.b: Residual changes, 1980-2000, Barro & Lee education measure.

Model	(1) FE	(2) Barro & Lee	(3) IIASA
Rank correlation	0.67** (p=0.02)	0.44 (p=0.12)	-0.17 (p=0.60)
R ² inequality	0	0.33	0.87
R ² share	0	-0.19	0.40
Observations	9	9	9

Finally, we perform a similar exercise by using the ratio of the minimum to the median wage for each country (obtained from the OECD) as an additional measure of labour market institutions. This restricts the sample to 173 observations from 7 countries. Interestingly, when it is added to the base regression, the level of the minimum wage has an individually significant negative effect on wage inequality even controlling for the interaction of collective bargaining with time, despite the very high correlation between the two variables. Many other variables become significant, with sometimes counterintuitive signs, but this seems to be an artefact of the sample rather than the addition of the minimum wage variable. Since the coverage-time interaction and minimum wage variables, along with education, are significant with the same sign in both regressions, it is not surprising that Table A.13.b shows that the residual changes are negative and both variables are very well explained (although with only 4 countries

represented this is of questionable value).

Table A.13.a: SUR with minimum wage.

Dependent variable:	(1) FE only		(2) w/ min		(3) w/o min	
	d91	Share	d91	Share	d91	Share
Coverage			0.06 (0.29)	28.0*** (10.3)	-0.009 (0.06)	8.55*** (3.59)
Coverage.time			-0.036*** (6.10)	-0.969*** (12.0)	-0.0444*** (13.1)	-0.340*** (6.21)
Minimum/median wage			-1.18*** (3.28)	-36.0*** (7.31)		
Minimum.time			0.00008 (0.01)	2.12*** (9.97)		
Education			-4.92*** (11.82)	-34.8*** (6.14)	-5.91*** (15.6)	-46.5*** (7.78)
RER			0.01 (0.19)	0.7 (0.82)	0.111* (1.78)	-1.6 (1.56)
ln(K/L)			-0.43*** (2.56)	-0.1 (0.06)	-0.887*** (6.29)	-5.17*** (2.27)
GDP growth			-0.006 (0.01)	-33.7*** (0.00)	-0.1 (0.22)	-30.5*** (4.41)
Observations				172		172
Countries				7		7
Residual correlation	0.52*** (p=0.00)			0.06 (p=0.43)		0.05 (p=0.49)

Table A.13.b: Residual changes, 1980-2000, with minimum wage.

Model	(1) FE only	(2) w/ min	(3) w/o min
Rank correlation	0.67** (p=0.30)	-0.33 (p=0.76)	-0.66 (p=0.31)
R ² inequality	0	0.97	0.99
R ² share	0	0.71	0.43
Observations	4	4	4

CHAPTER A5. CONCLUSIONS

This paper has examined the trends in wage inequality and wage shares since the 1970s for a sample of OECD countries. There is a trend towards higher wage inequality in most countries, and lower wage shares in all. Considering these trends jointly rather than individually, however, brings out an underappreciated point. They are inversely related at a country level: wage inequality has risen most in those countries where wage shares have fallen least, and vice-versa. This finding is robust to different measures of wage inequality and wage shares for time periods of twenty years and longer, although it weakens in shorter sub-periods. This is a surprising result, since the same forces, such as globalisation, technology, and institutions, are often blamed for both rising wage inequality and falling wage shares.

Since forces that explain both trends seem unpromising to explain why the trends are inversely correlated, we must look for alternative explanations. This paper has focused on capital accumulation and top wages, presenting a new production function which incorporates both capital-skill complementarity and a simple expression for the wage share, and calculating bottom 99% wage shares for eight OECD countries.

Our panel regressions, however, do not particularly support either of these explanations. Given issues with data quality and endogeneity, we should hesitate before regarding these results as definitive, but the exercise does not increase their plausibility. The most robust results in our data are that the time-collective bargaining interaction is correlated with lower wage inequality, and that wage shares are anti-cyclical. Using the IIASA measure of education, we also find that higher education levels are correlated

with lower wage inequality and, surprisingly, lower wage shares, but both of these results disappear when the Barro and Lee measure of education is used. While statistically the finding with the IIASA data can ‘explain’ why higher wage inequality and wage shares go together, it seems rather implausible that a more highly educated workforce should result in a lower wage share. When the education variable is excluded, or when the Barro and Lee measure is used, the explanatory power of our model over the puzzle disappears. The great unknown is the behaviour of the wage share: the model results for wage inequality are both empirically and theoretically more convincing and complete. The bottom 99% wage share does not produce notably different results from the full wage share. Excluding top labour incomes certainly narrows the differences between countries in the behaviour of the wage share, but it does not alter the strength of the correlation with changes in wage inequality.

In conclusion, the relationship between changes in wage inequality and changes in wage shares is still something of a mystery. Hopefully, however, this paper has succeeded in the modest aim of documenting and highlighting the existence of this previously ignored puzzle, and suggesting some possible lines of explanation. After all, given that rising wage inequality and falling wage shares have received so much attention as individual phenomena (the x co-ordinate of the US data point in Figure A.3 must have inspired dozens if not hundreds of papers), the fact that the two trends have such a strong and counter-intuitive relationship should excite considerable curiosity.

APPENDIX: DATA DESCRIPTION

Wage inequality Earnings deciles were obtained from OECD.Stat (Labour: Earnings: Decile Ratios of Gross Earnings) <http://stats.oecd.org/Index.aspx>, downloaded 7 July 2009.

Wage shares from AMECO 7.6 'Adjusted Wage Share' (AMECO is the Annual Macroeconomic database of the European Commission's Directorate General for Economic and Financial Affairs):

http://ec.europa.eu/economy_finance/db_indicators/db_indicators8646_en.htm,

downloaded 7 July 2009. The preferred definition is 'Adjusted wage share: total economy: as percentage of GDP at current market prices (Compensation per employee as percentage of GDP at market prices per person employed.)'. The alternative is to use factor cost rather than market prices. Both make two important corrections: the use of total compensation rather than just wages, and the imputation of average earnings to the self employed, as part of the wage share. See Gollin (2002) for a discussion of the issues.

Arpaia, Perez and Pichelmann (2009) have argued that adjusting for self employment at the national level is insufficient, and that this adjustment should be made at the industry level to avoid error from composition effects. The error, however, was found to be largest in the Mediterranean countries (Greece, Spain, Italy and Portugal) which are not used in this paper.

Collective bargaining is the AdjCov variable from the ICTWSS (Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts) Database Version 2 <http://www.uva-aias.net/208>, downloaded 16 July 2009. In the original dataset it is expressed as the percentage of the eligible workforce covered by collective bargaining, but for our regressions it is converted to a fraction in order to keep the number of decimal places in the coefficients manageable.

This variable has a correlation of 0.97 with the union coverage variable *uc* from the CEP-OECD data set described in Nickell (2006), based on the 240 observations which overlap with the ICTWSS measure. It also has a correlation of 0.83 with the *minimum/median wage ratio* from OECD.Stat (Labour: Earnings: Minimum relative to average wages of full-time workers), downloaded 7 July 2009, based on the 182 observations which overlap (observations for New Zealand from 1979-85 inclusive were deleted because of a large, anomalous dip). The ICTWSS variable was preferred over these others as having the largest coverage.

Capital-labour ratio. The capital stock was estimated using population, GDP/capita and investment/GDP (at constant prices) from Penn World Table 6.3, downloaded 16 October 2009 from http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.php. Following King & Levine (1994), an initial capital stock was calculated under the assumption of a steady state in which $K = I/(g_Y + d)$, where K is the capital stock, I is investment, g_Y is the growth rate of GDP (Y), and d is the depreciation rate. This expression is divided by Y to obtain an expression for the steady state capital/output ratio. This expression is evaluated using the arithmetic mean of I/Y from 1950-60. g_Y is calculated according to an arithmetic mean weighted 1/4 to the country and period in question, 3/4 to a world average of 4% per annum (e.g. if a certain country grew at 8%

p.a. from 1950-60, the value of gY used would be $0.25(8) + 0.75(4)$ or 5%). Depreciation is assumed to be 7% p.a. This estimate for the capital-output ratio is used to seed an initial value for K in 1951 by multiplying with the arithmetic mean of Y from 1950-52. After this, the capital stock is simply updated using the perpetual inventory method. The resulting estimate of the capital stock is divided by civilian employment from OECD.Stat (Labour: Labour Force Statistics: Annual Labour Force Statistics: ALFS Summary Tables, downloaded 19 August 2009) to give the capital-labour ratio.

Real effective exchange rate from the Bank for International Settlements <http://www.bis.org/statistics/eer/narrow0907.xls>, downloaded 6 August 2009. Monthly figures converted to annual using the geometric mean (which matches 2005=100 better than the arithmetic mean). Data is divided by 100 so that 2005=1 (the same adjustment, for the same reasons, as applied to collective bargaining).

GDP growth AMECO 6.1 'Gross domestic product at constant prices (OVGD)' , downloaded 6 August 2009.

$top1_Y$ from Leigh (2007) 'Top income shares for 13 developed countries' <http://econrssh.anu.edu.au/~aleigh/contact.htm>, downloaded 23 June 2009. This is available for all countries used in the paper except Denmark and Finland, beginning in 1970 and ending at various dates in the late 90s and early 2000s. $top1_L$ for United States from table B2 of Piketty and Saez (2007), updated at <http://elsa.berkeley.edu/~saez/TabFig2007.xls>, downloaded 1 September 2009.

Education The fraction of the population aged 25-64 (both sexes) with tertiary

education was constructed using the data from Lutz, Goujon and Sanderson (2007) and Samir et al (2008), downloaded 13 October 2009 from http://www.iiasa.ac.at/Research/POP/edu07/Education_database.zip and http://www.iiasa.ac.at/Research/POP/Edu07FP/Population%20Distributin%20and%20Means%20Years%20of%20Schooling%20_%20Education%20Projection%202000_2050.zip. Lutz, Goujon and Sanderson (2007) gives educational attainment at 5 year intervals from 1970-2000, while Samir et al (2008) projects attainment at the same frequency from 2005-2050 under several different scenarios (only the 2005 and 2010 observations from the Global Education Trend or ‘most likely’ scenario were used). Linear interpolation was then used to generate annual data. This is referred to as the IIASA dataset. A similar procedure was applied to the data from Barro & Lee (2001) <http://www.cid.harvard.edu/ciddata/ciddata.html> downloaded 7 August 2009. The Barro & Lee data only covers the period -2000.

Note on Interpolation. For the panel regressions, gaps of less than five years were filled by linear interpolation.

Appendix Table 1: Summary of data availability for panel regressions.

	Wage share	90/10	Collective bargaining	Minimum wage	Share99
Australia		75-	-07	85-	-03
Denmark		80-90, 96-07	-07	NA	NA
Finland		77-07	-00	NA	NA
France		-05	80-00	75-	-98
Japan		75-	80-00	75-	-02
Netherlands		77-05	-00	75-	-99
NZ	86-	84-	80-00	75-	86-02
Sweden		75-04	-06	NA	-04
UK			-07	99-	-00
US		73-	-07	75-	-04

Blanks indicate 1970-2008. NA indicates completely missing.

Gaps of less than 5 years were filled with linear interpolation and not shown here.

Share99 = bottom 99% wage share.

The capital/labour ratio, real exchange rate, GDP and education were available for all years and all countries from 1970-2008.

PART B

TWO NOTES ON LABOUR DEMAND

We revisit the recent controversy over the elasticity of demand for labour that began with Lewis and MacDonald (2002). It uses their chosen model, that of Allen (1938), to show that their results are invalid for full elasticities but may have some relevance for constant output elasticities. It also argues that this microeconomic model, and elasticities derived from it, is not particularly useful in a macroeconomic context.

The response of native wages to immigration depends on the behaviour of the capital stock. Much recent literature assumes that the return to capital is unaffected by migration in the long run, leaving average wages unchanged. This paper shows that, if immigration is modelled as a continuous flow rather than a one off shock, it reduces the average wage even in the long run. A calibration of a simple growth model with recent US immigration rates gives a reduction in average wages of 5%, larger than most estimates of its effect on relative wages.

CHAPTER B1: A NOTE ON THE ELASTICITY OF DEMAND FOR HOMOGENOUS LABOUR

There have been many attempts to estimate a labour demand curve for the Australian economy, which have naturally spawned many econometric controversies. Recently, however, there has been more fundamental disagreement about the interpretation of the empirical results. In particular, the methods used to derive the elasticity of demand for labour from estimates of the elasticity of substitution between capital and labour have come under attack. This chapter details Lewis and MacDonald's (2002) case that the usual procedure is incorrect, since it confuses nominal and real wages, and the response to it by Dowrick and Wells (2004). It is shown, using Lewis and MacDonald's own preferred theoretical framework derived from Allen (1938), that their criticism is invalid when applied to the full elasticity (including scale effects), although the constant output case is more ambiguous. The main argument of the chapter, however, is that the formula in question is purely microeconomic and applicable only at the industry level. Its use in macroeconomic models is completely unjustified.

Since this topic has already been covered rather exhaustively, it seems relevant to point out that more recent work such as Connolly and Stevens (2007) still refers to the debate, that Dowrick and Wells (2004) did not prove their results using Lewis and MacDonald's references to Allen via Hamermesh (1993), and that Hamermesh's standard work on labour demand is itself somewhat confused on the subject.

Lewis (1998) and Lewis and MacDonald (henceforth LM) (2002) argued that previous estimates of the elasticity of demand for labour in Australia were fundamentally flawed. While they employed some sophisticated econometrics to provide new estimates of σ , the elasticity of substitution between labour and capital, their main critique was theoretical rather than empirical.

The issue at stake is the interpretation of the elasticity formula $-(1-s)\sigma - s\eta$ (where s is the labour share of income and η is the own-price elasticity of demand for output). LM argued that this is a real wage elasticity: the (negative) percentage change in the demand for labour resulting from a one percent increase in the real wage. In response, Dowrick and Wells (2004, henceforth DW) defended the standard view that this formula is, in fact, only a nominal wage elasticity, and that to obtain the real wage elasticity it is necessary to account for change in the price level. They also argue that there is no particular reason to assume that η equals one, as LM do, and that one would need to estimate an aggregate demand curve as part of a complete macroeconomic model in order to justify using any particular value of η . Without doing this, it is only possible to estimate the elasticity of substitution σ and the constant output elasticity of labour demand $-(1-s)\sigma$ (again, LM and DW disagree over whether this is real or only nominal). Finally, LM (2004) stood by their original arguments, claiming that the price level is purely exogenous in the standard neoclassical model defined by Hamermesh (1993) and Allen (1938), and that DW are only generating different results by making arbitrary assumptions about price setting.

In order to evaluate these conflicting claims, I have turned to Allen (1938: 372-3), which LM and Hamermesh both cite as their original source. While I have used different notation and omitted some working, the assumptions and reasoning are identical.

Suppose that we have the constant returns to scale production function $Y = F(L, K)$, where Y is output, and L and K are labour and capital inputs respectively. Also define the nominal wage W , capital rental rate R , price of output P , and demand for output $D(P)$. In this model, W and R are exogenous, nominal variables, P is an endogenous nominal variable (although the representative firm takes the price level as given, it is endogenous in the model as a whole), and L , K and Y are endogenous, real variables. Then, impose the following equilibrium conditions:

Supply must equal demand,

$$Y = D(P). \quad (\text{B.1})$$

The representative firm maximises profits, $PY - WL - RK$, with respect to L and K . Hence, the marginal revenue product of labour must equal the nominal wage,

$$PF_L = W, \quad (\text{B.2})$$

and the marginal revenue product of capital must equal the cost of capital,

$$PF_K = R. \quad (\text{B.3})$$

(Subscripts denote partial derivatives.) Now, differentiating (B.1), (B.2) and (B.3) with respect to the nominal wage W gives

$$F_L L_W + F_K K_W = D_P P_W,$$

$$P_W F_L + PF_{LL} L_W + PF_{LK} K_W = 1, \text{ and}$$

$$P_W F_K + PF_{LK} L_W + PF_{KK} K_W = 0.$$

Now, the elasticity of substitution between labour and capital is

$$\sigma = \frac{F_L F_K}{F_{LK} Y},$$

and since F is homogeneous of degree 1,

$$F_{LL} = -\frac{K}{L} F_{LK} \text{ and}$$

$$F_{KK} = -\frac{L}{K} F_{LK}.$$

Therefore, we can write all second derivatives of F in terms of σ , Y , F_L and F_K . Then,

use (B.2) and (B.3) to substitute for F_L and F_K . Finally, write $s = \frac{WL}{PY}$ for the labour

share of output and $(1-s) = \frac{RK}{PY}$ for the capital share. Noting that $PY = WL + RK$ since

factors are paid their marginal products, we obtain the elasticity of the price of output with respect to the nominal wage,

$$P_w \frac{W}{P} = s. \quad (\text{B.4})$$

As Hamermesh (1993:24) states, ‘When the wage rate increases, the cost of producing a given output rises. In a competitive market a 1 percent rise in a factor price raises cost, and eventually product price, by that factor’s share. This reduces the quantity of output sold.’

Now, define the own-price elasticity of demand for output (the percentage fall in demand for output demanded caused by a one percent increase in price) as $\eta = -D_p \frac{P}{Y}$.

Then, the elasticity of labour demand with respect to the *nominal* wage is

$$L_w \frac{W}{L} = -(1-s)\sigma - s\eta. \quad (\text{B.5})$$

The first term, $-(1-s)\sigma$, is the substitution effect, which can also be interpreted as a constant output elasticity. As labour becomes more expensive relative to capital, each unit of output will be produced with less labour (and more capital). The second term, $-s\eta$, is the scale effect: the s percent increase in price from (B.4) implies an $s\eta$ percent decrease in output and employment. Because of the s percent price rise, the real product wage only rises by $(1-s)$ percent for every one percent increase in the nominal wage. We must divide (B.5) by this factor in order to obtain the *real* wage elasticity,

$$L_w \frac{w}{L} = -\sigma - \frac{s}{1-s} \eta, \quad (\text{B.6})$$

where $w = \frac{W}{P}$.

Constant Output Elasticities, the Cost of Capital and the Interest Rate

It is intuitive to follow the same logic when it comes to the (nominal) constant output elasticity, $-(1-s)\sigma$. Adjusting for the price rise would lead to a real wage elasticity of $-\sigma$. It is not self evident that this is the right thing to do, however: if output has not changed, then why should price? On the other hand, if one does not account for the price change, then the substitution and scale effect, measured in real terms, do not add up to (B.5).

The value $-(1-s)\sigma$ may also be derived from the cost minimisation problem $\min\{WL + RK\}$ with respect to L and K , holding Y and R constant, and raising W by one percent.⁹ This is completely independent of the demand for and price of output - if the analysis was performed in purely real terms i.e. $\min\{wL + rK\}$, with the real wage

$w = \frac{W}{P}$ rising by one percent and the real cost of capital $r = \frac{R}{P}$ held constant, the

⁹ See the Appendix to this chapter.

elasticity will again be $-(1-s)\sigma$, not $-\sigma$. Should the cost of capital be held constant in nominal or real terms? And how does this cost relate to the interest rate, which is usually considered as being identical?

In the marginal condition $R=P.F_K$ or the cost function $\{RK+WL\}$, R represents the nominal user cost of one unit of capital for one period. If we assume no inflation, depreciation or risk premium, and that financial assets yield a (nominal and real) interest rate of i , then to make owning capital equally attractive we must have $i=R/P_K$, where P_K is the purchase price of a unit of capital. There are now two possibilities. Firstly, output and capital may be different goods. If the industry or economy being considered (not just the representative firm) is a price taker in the capital goods market, P_K may be set equal to 1 without loss of generality. Then we have $i=R$. A constant interest rate implies a constant *nominal* cost of capital. Alternatively, in a one good model, $P=P_K$, so $i=R/P$. The interest rate here is equal to the *real* cost of capital. (Neither LM nor DW specify which assumption they use.)

Micro vs Macro Models

Allen's analysis is explicitly microeconomic, based on a representative price-taking firm in an industry with a given product demand curve. In this context, a one percent increase in the nominal wage is also a one percent increase in the real wage of labour measured in terms of consumer goods, assuming that the good being produced is an infinitesimal fraction of the consumption basket. The same formula can be applied to a macroeconomy by constructing an aggregate demand curve with elasticity η (which is not necessarily equal to one), and a horizontal aggregate supply curve. DW do this explicitly, and anyone using the Allen formulae does so implicitly. In this case, however, it is no longer plausible to assume that the change in the product price does

not affect real wages. This change from the micro to macro scales may account for some of the confusion.

Even with the appropriate adjustments, however, the Allen model does not seem particularly suitable as a source of standard formulae in macroeconomic work. Aside from the difficulties in choosing a plausible value of η and the appropriate assumptions for the cost of capital, there are simpler and more plausible alternatives. In the short run, a constant capital stock would imply a real wage elasticity of $\frac{-\sigma}{1-s}$.¹⁰ In the long run, a constant return to capital (in a Solow-Swan steady state or under perfect capital mobility) implies an endogenous real wage (infinitely elastic labour demand). These are the alternatives used in studies of immigration such as Borjas and Katz (2005) and Ottaviano & Peri (2005). A more sophisticated dynamic model such as TRYM could also trace out the adjustment path (e.g. Song, Freebairn and Harding 2001). These assumptions would seem to be more relevant when considering an economy-wide wage shock, which is after all the motivation for estimating labour demand elasticities at a macro level. It is worth noting that even the canonical labour demand text, Hamermesh (1993: 339-40), uses the constant output elasticity $-(1-s)\sigma$ when discussing employment fluctuations over the business cycle!

Summary and Conclusion

In the Allen (1938: 372-3) model used by Hamermesh (1993) and Lewis and MacDonald (2002) as the basis for their calculations, the price of output is endogenous and is affected by the nominal wage. Therefore, it makes no sense to calculate a labour demand elasticity with the output price held constant. In this regard, Lewis and

¹⁰ Differentiate the first order condition $F_L = W/P$ with respect to W/P assuming constant K , and then make the appropriate substitutions from section III.

MacDonald's criticism of common practice is unjustified. Otherwise, the use of this microeconomic model to derive macro-level labour demand elasticities is problematic. It seems preferable to simply interpret σ as an elasticity of substitution, which is sufficient to allow comparison of different estimates, and to make an explicit assumption about the supply of capital if a labour demand elasticity is required.

Appendix

The Lagrangian for the cost minimisation problem is $WL + RK + \lambda(Y - F(L, K))$. The first order conditions combined yield $WF_K = RF_L$, which when differentiated with respect to W becomes $F_K + W(F_{KK}K_W + F_{KL}L_W) = R(F_{LL}L_W + F_{LK}K_W)$. Similarly the constraint $Y = F(L, K)$ implies $F_L L_W + F_K K_W = 0$. Making the same substitutions as before for the second order derivatives, but noting that the first order conditions now contain the Lagrangian multiplier e.g. $\lambda F_L = W$, we obtain the elasticity

$$L_W \frac{W}{L} = \frac{-\lambda Y}{(WL + RK)^2} RK \sigma.$$

Assuming that we begin from a position of profit maximisation, where $\lambda = 1$ and labour and capital are paid their marginal products, this reduces to $-(1-s)\sigma$.

It is also possible to obtain the value of $-\sigma$ for the real wage, constant output elasticity if the rise in the nominal wage is accompanied by a fall in the nominal cost of capital that keeps the profit maximising level of output, and hence price, constant:

$(F_L L_W + F_K K_W)dW + (F_L L_R + F_K K_R)dR = 0$. Combining this with the results obtained under the assumption of profit maximisation¹¹ we find the total elasticity

¹¹ Including (B.4), $K_W \frac{W}{K} = s(\sigma - \eta)$, and, by symmetry, the elasticities of L and K with respect to R .

$$\frac{dL}{dW} \frac{W}{L} = L_W \frac{W}{L} + L_R \frac{R}{L} \left(\frac{dR}{dW} \frac{W}{R} \right) = -\sigma,$$

which is also a real wage elasticity since price is constant. I would argue that this is a reasonable interpretation of DW's equation 7, which is a labour demand curve $\ln(L) = \dots - \sigma \ln(W/P) + \ln(Y) \dots$, implying a constant output real wage elasticity of $-\sigma$. This demand curve is derived from the marginal condition $PF_L = W$. Since this is a profit maximising condition, the output term on the right hand side is endogenous. (As can be seen above, the first order conditions in the cost minimisation problem both contain a Lagrangian multiplier.) It is not consistent to arbitrarily set Y constant – there must be some force offsetting the rise in W to keep the profit maximising level of output constant.

CHAPTER B2: A NOTE ON IMMIGRATION AND AVERAGE WAGES

In recent years, there has been a vigorous debate over the impact of immigration on the US labour market, particularly on the wages of unskilled native workers. A common approach (see Borjas 2003, Borjas and Katz 2005, Ottaviano and Peri 2005, 2006 and Aydemir and Borjas 2006) is to estimate a multi-level CES production function for the US economy, with the labour input sub-divided by education and experience. Estimates of the elasticity of substitution between different groups of workers combined with the supply of immigrants in each group are used to find the effect of immigration on relative wages. The latest estimates of this effect for US born high school dropouts are between -1.1% (Ottaviano and Perlini 2006) and -3.8% (Aydemir and Borjas 2006). This is only a small share of the observed 24.4% fall in this group's wages, relative to the average, between 1990 and 2004 (Ottaviano and Perlini 2006:32).

The *absolute* effect of immigration on wages, however, also depends on the behaviour of the capital stock. The standard assumption in this literature is a constant return to capital in the long run, which implies that immigration does not change the average wage. Only changes in relative wages need to be considered. Ottaviano and Peri (2006:10) give the most explicit justification: "As for the long-run response of capital, any model of growth (Solow, 1956; Ramsey, 1928) as well as empirical evidence imply that capital adjusts to maintain its real return (and capital output ratio) constant."

This approach implicitly treats immigration as a one-off shock, which increases the size, but not the growth rate, of the labour force. While this may be appropriate for particular episodes such as the Mariel boatlift (Card 1990), it is clearly not an accurate description of migration in general.¹² Once immigration is treated as a continuous flow, adding a little bit to the population every year, it can be seen that a change in the rate of immigration will change the growth rate of the labour force. This in turn changes the steady state growth path, in particular the capital stock per worker on which the average wage depends. In this chapter, we derive the effect of a change in labour force growth on the average wage in a Solow-Swan model. A simple back of the envelope calculation of the size of this effect in the United States, indicates a reduction of over 5% in the average wage, although, for various reasons, this is probably an overestimate.

Theory

Consider the standard Solow-Swan model e.g. in Romer (2006: ch.1), with a Cobb-Douglas production function,

$$Y = (AL)^\alpha K^{1-\alpha}. \quad (\text{B.7})$$

The equation of motion for the capital stock is

$$\frac{\partial K}{\partial t} = sY - \delta K$$

where s is the savings rate and δ is the depreciation rate. The steady state with a constant capital stock per effective worker $\left(\frac{K}{AL}\right)$ is given by

$$s \frac{Y}{AL} = (\delta + n + g) \frac{K}{AL}$$

¹² Ottaviano and Peri (2006:10): “Immigration is an ongoing phenomenon, distributed over years, predictable and rather slow . . . It is reasonable, therefore, to think of this issue more dynamically with investments continuously responding to the flow of immigrant workers.”

where n and g are the growth rates of the labour force L and labour augmenting productivity A respectively. In this steady state, the capital stock per *actual* worker is given by

$$\ln\left(\frac{K}{L}\right) = \frac{1}{\alpha} [\ln(sA) - \ln(\delta + n + g)] \quad (\text{B.8})$$

using (B.7). The derivative of (B.8) with respect to labour force growth is

$$\frac{\partial \ln(K/L)}{\partial n} = \frac{-1}{\alpha(\delta + n + g)}. \quad (\text{B.9})$$

Now, from the marginal product condition $w = \frac{\partial Y}{\partial L}$ and (B.7), the elasticity of the average wage w with respect to the capital stock per worker is

$$\frac{\partial \ln w}{\partial \ln(K/L)} = (1 - \alpha). \quad (\text{B.10})$$

Combining (B.9) and (B.10) using the chain rule gives

$$\frac{\partial \ln w}{\partial n} = \frac{-(1 - \alpha)}{\alpha(\delta + n + g)}. \quad (\text{B.11})$$

This derivative is the semi elasticity of the average wage with respect to the population growth rate – the percentage change in the steady state wage resulting from a one percentage point increase in labour force growth. This is a level effect – in the new steady state the wage will continue to grow at rate g but on a permanently lower path.

Empirics

How big is this fall in the average wage? A labour share α of $2/3$ is typical, and Romer (2006:25) calibrates depreciation plus population and productivity growth ($\delta + n + g$) to 0.06. These numbers imply a value of $-8\frac{1}{3}$ for the semi elasticity in equation (B.11). Legal migration of people aged between 15 and 64 to the US was around 1 million per

year for fiscal years 2004 through 2006 (Office of Immigration Statistics 2007). In addition Hanson (2006:7) estimates a net illegal inflow of 350 000 to 580 000 per year. The size of the civilian labour force is 152 million with participation rate of 66% (BLS 2007). The same ratio applied to immigrants (possibly an underestimate, particularly for illegals) would mean an annual addition of about 1 million - $\frac{2}{3}$ of a percentage point - to labour force growth. Multiplying by $-8\frac{1}{3}$ implies that migration reduces the average wage in the steady state by over 5%. This is larger than the estimated 1.1 to 3.8% change in dropout wages, relative to the average, mentioned in the Introduction.¹³

The above analysis assumes a closed economy with respect to capital. Will investors respond to lower wages and higher profits with capital inflows that restore the previous rate of return? The United States is surely too large to be a price taker in international capital markets. Furthermore, much of the current capital inflow is being driven by central banks, which are not going to increase their holdings of US assets in response to a fall in US wages.¹⁴ Even if capital mobility eliminated a majority of the effect of migration on the average wage, there could still remain an impact of comparable size to the changes in relative wages estimated in the literature.

Another objection might be that the capital-labour and capital-output ratios given in Ottaviano and Peri (2006:30,50) rule out significant effects from immigration. However, these ratios only show convergence to a long run trend without specifying the determinants of that trend. A lower rate of immigration would have meant a different steady state, with slower labour force growth and a higher capital-labour and capital-output ratios.

¹³ This calculation is not strictly comparable with the literature discussed, since the labour input is a simple headcount rather than a CES aggregate. However, it should give some indication of potential magnitudes, as well as being of interest in its own right.

¹⁴ A perverse effect on capital flows is possible – lower US wages make US tradeables more competitive, reducing the trade deficit at a fixed exchange rate and therefore lowering foreign central banks' accumulation of USD reserves.

Conclusion

The effect of immigration on native wages depends crucially on the behaviour of the capital stock. Modelling immigration as a one off shock, as is done in much of the literature, minimises its effects by implying that the average wage is unchanged in the long run. Treating immigration more realistically, as a continuous flow, reveals that it changes the rate of growth of the labour force, which affects the capital stock per worker and thus the average wage, even in the long run. A simple calculation of this effect in the standard Solow-Swan model implies that current immigration flows to the US would reduce the steady state average wage by over 5%, if immigration was not matched by additional capital inflows. Even if the majority of the fall in wages was arbitrated away by foreign investment, the remainder could still be comparable to the previously estimated effect on the relative wages of native unskilled workers.

PART C

WHY DON'T RELATIVE WAGES AFFECT EMPLOYMENT (VERY MUCH)?

Many empirical studies have found little or no employment penalty from minimum wages and other interventions to raise the price of labour. These findings seemingly cast doubt on the validity of the Law of Demand in labour markets. This essay argues that several common explanations for these findings lack sufficient evidence to be persuasive. It proposes an alternative: that the demand for labour is much less elastic at the occupational level than at the aggregate level. This hypothesis is shown to be consistent with a range of stylized facts about the labour market, while the rival explanations are not.

CHAPTER C1. INTRODUCTION

Clearly these advocates very much want to believe that the price of labor - unlike that of gasoline, or Manhattan apartments - can be set based on considerations of justice, not supply and demand, without unpleasant side effects.

Paul Krugman, review of *Living Wage*, *Washington Monthly*, September 1 1998.

There is a firm belief among economists that, all else being equal, an increase in the price of a good will reduce the amount purchased by consumers. So strong is this belief that it has become known as the Law of Demand. While long and diligent search may have revealed the occasional exception in the form of Giffen goods or status symbols, one may, on the whole, say that the empirical evidence for this proposition is as compelling as the theory.

On the face of it, there seems to be no particular reason why labour should be exempt from this law: why, if the wage rate (or other costs of employment) rises, employers will not respond by reducing the number of workers they hire. Indeed, since the demand for labour is usually a derived demand – workers are hired to produce goods and services, the revenue from which must cover the costs of their employment – the argument seems doubly strong. Not only will an increase in wages increase production costs and the product price, which will in turn reduce the final sales of the product and therefore the demand for labour in its production (the *scale effect*), but it will also provide an incentive to adopt techniques that produce the same output with less use of labour (the *substitution effect*, so called because of the necessity to find other factors of

production – machinery, energy etc. – to substitute for the diminished application of labour). So much is standard in any microeconomics or labour economics text.

The logic seems compelling. Yet, as we will see in chapters C2 and 3, it has been hotly contested both empirically and theoretically. Moreover, the dispute is not purely academic, but has important policy and political implications. If wages could be raised by fiat with little or no effect on employment, it would provide a popular and seemingly painless way to raise the income of a large part of the population. Conversely, if there was a large employment penalty, the wage hike would hurt the very people it was ostensibly designed to aid.

In the political arena, it is interesting to note that, despite several decades of free market reform that have left rent and commodity price controls a distant memory in most jurisdictions, 21 out of 30 OECD countries have a statutory national minimum wage, and most of the others rely on collective bargaining and industry-specific laws to achieve the same effect (Martin & Immervol 2007). One would have to look at infrastructure natural monopolies such as transport, power, and telecommunications, or sectors like defence, health, and education where the government is a major buyer, to find a market in which government still intervenes so directly in price formation. Furthermore, while most modern states have some kind of agency dedicated to detecting and punishing anti-competitive behaviour in the product market, the right of combination in the labour market is endorsed in Article 23 of the Universal Declaration of Human Rights. For some reason, lawmakers still seem to believe that wages *can* be set based on ‘considerations of justice’, even when they have abandoned this belief with respect to gasoline and apartments. If an author may be forgiven for concentrating on his own backyard, the Australian experience in the last few years provides a perfect illustration of this contrast. Large and rapid rises in the prices of petrol, food, and

housing did not result in any kind of price controls being adopted, or even seriously advocated as a policy response. In the same period, an attempt to weaken (not abolish) statutory minimum wages and conditions in a number of occupations was met with outrage, and was the key issue in the fall of a government which had held power for over a decade (Brett 2007, Roy Morgan 2007).

Simply because a belief is commonly and stubbornly held by the public is not, of course, a guarantee of its correctness. Public choice theory or behavioural economics might provide a number of explanations for why popular delusions about wages and employment are particularly hard to shift. On the other hand, the beliefs of the public, however crude and uninformed, may reflect an important aspect of reality. Such an argument is made in the following chapters.

We begin in chapter C2 with a survey of the empirical evidence on the effect of minimum wages, equal pay laws, and wage setting institutions on employment. This survey reveals a lack of consensus on whether these interventions do, in fact, have an employment penalty. Even those studies that do find a negative employment effect typically report that it is quite small.

In chapter C3 we move on to possible theoretical explanations for this lack of consensus. First, we consider the possibility of mismeasurement: that the part of the literature finding a lack of employment effects is systematically biased in some way. Then, assuming that this is not the case, monopsony, efficiency wage and aggregate demand theories are considered as alternate possibilities. It is argued that all of these are unconvincing for various reasons.

Chapter C4 presents an alternative hypothesis: that the explanation lies in the nature of production technology, not in mismeasurement or some peculiarity of the labour market. Specifically, it is argued that the demand for labour becomes much less

elastic as labour is disaggregated by occupation. This argument is illustrated with a ‘Leontief/Cobb-Douglas’ function in which the labour input in a Cobb-Douglas function is a Leontief aggregate of different occupations. Various properties of this function are derived, and some objections considered.

The superiority of this explanation over its rivals is further argued in chapter C5. Here, a range of stylized facts about the labour market are presented. While the technological theory is a good fit for all of them, the other candidates are compatible with hardly any.

Finally, chapter C6 presents some richer versions of the basic model in chapter C4. These show that the technology hypothesis can be extended to take account of substitution between different goods, nonzero substitution between different types of labour, capital-skill complementarity, and heterogeneous skill levels within occupations, without losing its essential properties. Chapter C7 summarises and concludes.

CHAPTER C2. EMPLOYMENT EFFECTS OF MINIMUM WAGES & OTHER INSTITUTIONS

The inverse relationship between quantity demanded and price is the core proposition in economic science . . . Just as no physicist would claim that ‘water runs uphill’, no self-respecting economist would claim that increases in the minimum wage increase employment. . . . Fortunately, only a handful of economists are willing to throw over the teaching of two centuries; we have not yet become a bevy of camp-following whores.

James Buchanan (1986 Nobel laureate in economics), *Wall Street Journal*, April 25 1996.

In this chapter, we review the empirical literature on the effect that minimum wages, equal pay for women, and wage setting institutions have on employment. Although the studies are grouped into these categories for convenience, it must be emphasised that they are all variations on the same basic theme – whether forcing employers to pay higher wages will cause them to reduce the number of workers they employ. For this reason, the term ‘wage floor’ is sometimes used as shorthand to cover all such situations, whether they are the result of a statutory minimum, collective bargaining, or some other institutional arrangement.

Minimum wages

Card and Krueger’s book *Myth and Measurement* (1995) is probably the best known challenge to the proposition that a binding minimum wage will necessarily reduce employment. The book is based on several of the authors’ papers, some co-authored

with Lawrence Katz. The most famous of these was Card and Kreuger (1994), which examined the response of New Jersey fast food restaurants to a rise in that state's minimum wage. Based on their own survey data, they found that employment actually increased in these establishments, compared to those in neighbouring Pennsylvania (in which the minimum did not rise). In addition, this effect was more pronounced in those New Jersey stores with the lowest initial wages (where the rise in the minimum had the biggest effect), and was not seen at all in those stores which had an initial wage above the new minimum (and thus were not directly affected by the increase). This would seem to rule out any state-specific shock. Neither did they find any substitution of part- for full-time workers, reductions in fringe benefits, or reduction in store openings.

These results were highly controversial, as shown by the quote at the beginning of this chapter. In particular, the accuracy of the survey data was questioned (Brown 1995, Welch 1995). Neumark and Wascher (2000) attempted to replicate the study using payroll data from an alternative source, and found that the New Jersey minimum wage had a negative effect on employment. Card and Kreuger (2000) responded by reproducing their earlier results with data from the Bureau of Labour Statistics, although with lower statistical significance (most of the estimated employment effects were statistically indistinguishable from zero). Angrist and Pischke (2009:230-1) suggest that *trend* growth in employment was lower in Pennsylvania than New Jersey, invalidating the use of that state as a control.

Whatever the final judgement on this debate, it relates to only a small part of the evidence in *Myth and Measurement*. As well as the work on the fast food industry based on Card and Kreuger's own surveys (and a similar study on Texas), the book included other cross-state comparisons. Both the 1988 California and 1990-91 federal increases in the minimum wage were studied, using data from the Current Population

Survey. In both cases, those states most affected by the rise did not show any evidence of employment losses relative to states where the change had little or no impact on wages. This result held true whether teenage, retail or restaurant employment was considered.

In addition, the book highlighted weaknesses in the existing literature. A meta-analysis of the existing time series literature found evidence of specification searching and/or publication bias, which severely undermined the previous consensus estimate of a one to three percent fall in teenage employment in response to a ten percent increase in wages (Brown, Gilroy and Cohen 1982). Analysis of particular papers found severe specification issues. Of particular interest was the discussion of Puerto Rico, where the minimum wage has a much greater effect than in the rest of the United States due to the lower average level of wages. Despite this, it is possible to eliminate negative employment effects from the standard regression equation by simply weighting the observations by industry size.

A large amount of work on minimum wages has, of course, been done since 1995. Neumark and Wascher (2006) surveyed over 90 minimum wage studies from many different countries published in the subsequent decade. Although two thirds of these find negative employment effects (not always statistically significant), and less than ten find positive effects, they conclude that 'Clearly, no consensus now exists about the overall effects on low-wage employment of an increase in the minimum wage.' (p.115) Worthy of particular attention is OECD (1998), which combines data from nine countries in a panel regression. Various specifications consistently find small, negative employment effects for teenagers (of roughly the same magnitude as those in Brown, Gilroy and Cohen), and little effect for older workers.

Equal pay

Equal pay laws are another institutional mechanism which can alter the wages paid by employers. The concept of 'equal pay' can be difficult to define philosophically – equal for all men and women, or just those working full time, doing the same job, or jobs that require the same level of education and experience? Despite these ambiguities, in practice such laws have had the effect of substantially raising women's wages relative to men's.

Australia implemented such regulations between 1969 and 1975, through its centralised wage fixing tribunals. First implementing the principle of "equal pay for equal work", which had little effect on pay,¹⁵ the tribunals moved on to the more ambitious "equal pay for work of equal value". Previously, occupations that were predominantly female had been awarded lower minimum rates of pay, based on the principle that a working man should be able to support a wife and child, while a working woman only had to support herself. This principle was now abandoned, with the result that women's wages rose by about 30% relative to men's. This change was seen both in the award rates of pay and women's actual earnings.

Such a large change in the space of a few years would potentially have large effects on the economy, including female employment. Yet Gregory and Duncan (1981), from whom the above description is taken, find that the changes in employment as a result of this wage shock were rather small. They estimate that the elasticity of substitution between male and female labour was only 0.3 for the economy as a whole, 0.6 in manufacturing (possibly biased upwards by tariff cuts and increasing international competition during the period), 0.3 in services and zero in government.

¹⁵ Women were explicitly paid less than men in only a few, mostly public service occupations. The principle had mainly been conceded elsewhere for the very unfeminist reason of preventing women from undercutting men with profit seeking employers.

Manning (1996) similarly found that the Equal Pay Act in the United Kingdom had no detrimental effect on female employment, despite a 10% rise in the relative pay of female workers.

Institutions

Aside from the level of their statutory minimum wage and the existence of equal pay laws, countries also differ more broadly in their wage setting institutions, such as the extent of and protection given to collective bargaining, and the generosity of unemployment benefits. Potentially, these differences affect both the distribution of wages and the degree of wage flexibility in response to demand or supply shocks. For example, it has been argued that skill-biased technical change has been reducing the demand for less skilled workers. Countries with more flexible wages can avoid unemployment by allowing wage inequality to increase, while countries which maintain the relative wages of the unskilled will see unemployment rise. This 'diabolical tradeoff' (Krugman 1994) was a popular explanation for the strong employment performance of the United States relative to Western Europe in the late twentieth century.

This argument was questioned by Gregory (1995), Krueger and Pischke (1997), and Card, Kramarz and Lemieux (1999). Comparing the United States to Australia, Germany and Canada and France respectively, they show that, indeed, the United States has experienced both higher employment growth and a greater rise in wage inequality. However, the stronger job growth in the US has not been concentrated at the bottom of the wage distribution, as one would expect if flexible wages were the reason. Instead, job growth has been higher across the board. Similarly, Nickell and Bell (1996) have shown that unemployment in the US was equally or more concentrated among the low

skilled relative to European countries, while Howell (2002) finds no correlation between changes in unemployment and wage inequality within the OECD as a whole. Again, this is the opposite of what the ‘diabolical tradeoff’ predicts.

Summary

There are strong theoretical arguments that a binding wage floor will reduce employment among affected workers, whether it is the result of a minimum wage, equal pay law or some other institutional arrangement. Yet we have seen that there is no consensus in the empirical literature on whether these interventions reduce employment at all, let alone on the size of the effect. Some studies even find a positive effect on employment, but this is unusual. Furthermore, even those studies that do find statistically significant employment losses generally find that the elasticity is quite small, so that the affected workers as a group may enjoy higher total incomes despite some of them losing their jobs.¹⁶ In the next chapter, we consider possible explanations for this empirical puzzle.

¹⁶ One cannot, however, simply quote an elasticity with respect to the minimum of, say, -0.1 to -0.3 for teenage labour and say that the demand is inelastic, since some teenagers will earn more than the minimum wage. We would need to know the elasticity of the average wage for teenagers with respect to the minimum to make this calculation.

CHAPTER C3. MONOPSONY AND OTHER EXPLANATIONS

We believe there is a need to reformulate the set of theoretical models that are applied to the low-wage labour market . . .

Card and Krueger (1995:397)

Since the findings in the previous chapter are somewhat counterintuitive, at least for a trained economist, they have naturally provoked controversy. Many have flatly denied their validity. Some of the more common objections are summarised first, under the heading of 'mismeasurement'. If one accepts that there is a puzzle to be solved, however, then one must enter the equally contentious area of potential explanations. Theoretically, several consistent arguments may be made as to why higher wages need not reduce employment. The claim that employers enjoy significant monopsony power in the labour market is perhaps the most common. Efficiency wages and aggregate demand are also considered.

Mismeasurement?

One way to deal with a puzzle is to argue that it does not really exist: that the data is inaccurate or has been misinterpreted. In this case, the first option is difficult to sustain. Aside from Card and Krueger's fast food surveys (which we have seen were only one

part of their work), all of the cited studies were based on government or other standard statistical sources.

This could still be a problem if official sources do not measure employment accurately in the first place. We might, for example, conjecture that illegal immigrants account for much of the low-wage job growth in the United States in recent decades (Hanson 2006), but that because they are illegal, they are not counted in the employment statistics, and that, furthermore, they are fired before native workers when employment contracts (so that the jobs lost to a minimum wage hike do not show up). If the United States has experienced a large amount of unmeasured low-wage job growth, then perhaps that country's more flexible relative wages really were the cause of its stronger jobs growth relative to Canada, Western Europe and Australia. For this explanation to work, however, illegal employment would have to have grown more rapidly in the US than elsewhere, which seems plausible for Canada and Australia but less so for Europe with migration from North Africa and Eastern Europe. Indeed, because of Europe's high payroll taxes and restrictive labour laws, some have argued that the black economy is more important there than in the United States (Schneider & Enste 2000). Of course, one may also argue that informal employment is irrelevant to the argument if the minimum wage does not apply to that sector in the first case: the key question is the effect of the minimum wage on the (legal) covered sector, which is presumably measured in the official statistics.

If the data itself is hard to question, that only leaves the question of interpretation. Perhaps there are large employment effects hidden in the data and the researchers have simply not asked the right questions to extract them. While correct specification is always a vexed issue in econometrics, it is not particularly likely to be a problem here on two grounds. First is the relative simplicity of the methods, which

generally consist of simple comparison of treatment and control groups, or re-estimation of equations from previous studies. Second is the range of the evidence, which includes a range of shocks, statistical methods, countries and researchers. Any bias due to individual idiosyncrasies on any of these dimensions should not be enough to contaminate the entire literature.

One more systematic issue that has been raised is the appropriate time period to allow for employment to adjust in response to a wage shock. For example, Brown (1995) and Hamermesh (1995) have suggested that Card and Kreuger's 'before' and 'after' observations (typically six months either side of a minimum wage increase) are both inaccurate: the 'before' observation comes after the minimum wage is announced (and thus may already include some adaptation) and the 'after' observation leaves insufficient time for full adjustment. Furthermore, since minimum wage increases are generally eroded by inflation, the response we see may underestimate the effect of a permanent increase. (This point may be raised more generally about any specification that employs a particular lag, which is typically one year.) While doubtless these points have some validity, are they strong enough to reverse and not just attenuate the results? One must note that the first two objections seem somewhat contradictory - one implying extremely rapid adjustment, and the other extremely slow adjustment. They also apply to the substitution effect (the adjustment to production techniques that use less low-skilled labour), but not the scale effect (the reduction in output due to the increase in price). As will be seen in the next chapter, these problems do not seem so serious when it comes to the response of total employment to an increase in the average wage. Ironically, Hamermesh (1993:294) himself states that 'The speed of adjustment of employment or worker-hours in response to shocks is fairly rapid. Taking the approach of static expectations, most of the gap is made up within a year. Nearly half is covered

within one quarter of a shock . . . Adjustment of the employment of unskilled workers is faster than that of skilled workers.'

The strongest rebuttal to this point, however, is provided by the cross-country literature on wage inequality and employment that was discussed at the end of the previous chapter. This literature deals with time periods measured in decades. It is hard to think of any plausible costs that would delay adjustment for that length of time.

Monopsony

Invoking the law of demand in the labour market assumes that individual employers have access to an unlimited supply of labour at a fixed wage. We might instead assume that firms face a tradeoff between the wage they pay (or other costs of employment) and the number of workers they can hire. Such an assumption is the foundation of monopsony models of the labour market. Under certain conditions, a binding wage floor can sometimes increase employment in these models.

The simplest model of monopsony is that of an individual firm facing an upward sloping labour supply curve. The firm maximises profits by setting a wage below the marginal product of labour, just as a monopoly maximises profits by pricing above marginal cost.¹⁷ A binding wage floor can actually increase employment as long as it is set below the marginal product of labour. More sophisticated models of monopsony and 'oligopsony' (with multiple employers) are described in Boal and Ransom (1997) and Manning (2003). As in the simpler version, they assume that individual firms face some tradeoff between labour costs and labour supply, leading to a gap between the marginal product of labour and the wage. Search models of the labour market can have

¹⁷ The profit maximising condition sets the marginal product of labour equal to the marginal cost, $w + L(dw/dL)$, where $dw/dL > 0$. Counterintuitively, a binding minimum wage can lower the marginal cost of labour by setting dw/dL to zero – the firm no longer has the option of paying a lower wage and accepting the consequent reduction in labour supply.

similar implications (e.g. Rocheteau and Tasci 2008), although the wage is often set through a bargaining process rather than unilaterally by the employer.

This explanation is intuitively appealing. As Manning (2003) states repeatedly, a wage cut of one cent would not cause all workers to quit a firm immediately. Card and Kreuger (1995) suggested monopsony as an explanation of their minimum wage findings. More recently, Manning (2003) has argued that monopsony explains a wide range of puzzling labour market phenomena such as the employer size-wage effect, wage dispersion, and returns to tenure.

Yet, for our purposes, the crucial question is not the existence of monopsony power *per se*, but the size of the gap between wage and marginal product in actual labour markets. It is only in this gap that a binding minimum wage will not reduce employment below its initial level.

In the individual firm model the 'rate of exploitation', the proportion by which the marginal product of labour exceeds the wage, is equal to the inverse of the elasticity of labour supply to the individual firm. (This is analogous to the Lerner index for a firm's product market power.)¹⁸ Card and Kreuger (1995: 376-7) argue that a rate of exploitation of 10-20% is 'potentially plausible', based on an elasticity of supply of 5-10, but their own estimates suggest an elasticity between 20 and 50 ie a rate of exploitation between 2 and 5%. Manning (2003) admits that direct estimates of this elasticity do not consistently support a large degree of monopsony, and relies on more indirect evidence.

More recent work has not changed this situation. Hirsch and Schumacherb (2005) find that monopsony power is not evident in the labour market for registered nurses in the US, which is often cited as a classic example of monopsony. Fakhfakh

¹⁸ From above we have $MPL = w + L(dw/dL)$ which rearranges to $(MPL - w)/w = (L/w).(dw/dL)$. C.f. the Lerner index: $(P - MC)/P = -(Q/P).(dP/dQ)$.

and Fitzroy (2006) find a long run elasticity of labour supply to the individual firm of 10, implying a rate of exploitation of 10%. (Short run effects may increase this by another 4 to 6 percentage points.) Manning (2006) estimates a more complicated dynamic model based on recruitment costs and finds a rate of exploitation of only 3%, although he argues that this is an underestimate.

So, while monopsony may be an important feature of the labour market, it has yet to be proven that it can explain the full range of evidence considered in the previous chapter. For example, Card and Krueger (1995) consider changes in the minimum wage from \$3.30 to \$4.25 and \$4.25 to \$5.05 per hour (27% and 19% respectively), and Gregory and Duncan (1981) a rise in women's relative wages of 30%. These rises are larger than any monopsony wedge from the above estimates. Also, they did not come from a starting position of an unregulated labour market, but off a base of already binding minima. A large part of the wage rises would *not* be absorbed by the wage-marginal product gap and should therefore reduce employment below its initial level, even under the monopsony assumption. Yet such reductions were not observed, or were quite small.

Efficiency wages

Another way in which the negative effects of a minimum wage may be offset is if it increases labour productivity at a given level of employment. (It is not sufficient that productivity rise as a result of a higher capital-labour ratio or higher average skill levels, in response to the least skilled workers being made redundant.) If workers are prepared to work harder to justify their continued employment at a higher wage, employment may increase along with the wage. This result is possible both in efficiency wage settings where effort is not observable (Manning 1995) and in the standard competitive

model where effort is observable and hence subject to contract (Deltas 2007). It depends, however, on rather strict conditions which the authors do not support with empirical evidence, or even spend much time trying to justify.¹⁹ The full information story also has the rather disconcerting implication that workers are *worse* off with higher wages and more employment, because of their valuation of effort. (This is rather similar to the case when higher wages are offset by lower working conditions or fringe benefits.)

Aggregate Demand

From a macroeconomic point of view, sticky prices or bad monetary policy may produce an interest (and/or exchange) rate which acts as a constraint on employment, no matter how flexible wages are (Barro and Grossman 1971, Romer 2006: 246). Since the demand for labour is a derived demand, there is no point in employing a worker, no matter how low their wage, if it is impossible to sell the output they produce. In this situation an additional worker's value marginal product is zero, whether their physical marginal product is greater than their real wage (expressed in terms of the current but non market clearing product price) or not. Essentially, the labour demand curve becomes vertical once a certain level of output has been reached. As with monopsony, an increase in wages need not reduce employment as long as the wage remains below the marginal product of labour.

The importance of aggregate demand might provide an explanation for why real wages tend to be acyclical or procyclical, which has been an issue since Dunlop (1938). Galbraith (1998) also argues that wage inequality and unemployment tend to rise and

¹⁹ In the efficiency wage model, the elasticity of the marginal revenue of a wage increase with respect to employment must be greater than one. In the full information model the workers' coefficient of relative risk aversion must be less than one, and the demand for labour highly elastic.

fall together. If too high wages for unskilled workers were the cause of unemployment, there should be no such relationship. Indeed, one would expect the opposite: unemployment could only fall when the relative wages of the less skilled fell, increasing inequality.

It would be rather heroic, however, to assume that this is the typical state of an economy, rather than a temporary condition during depressions. It also does not rule out substitution (as opposed to scale) effects: even if total output is fixed by aggregate demand, it might still be profitable to employ labour-saving techniques to produce that output more cheaply.

Summary

The literature arguing that wage floors do not substantially reduce employment has met with a variety of responses. Some argue that the finding is simply mistaken, while others see it as evidence that the labour market is better described by monopsony or efficiency wage theory than perfect competition, or that aggregate demand rather than the real wage is the binding constraint on employment. This chapter has argued that none of the above explanations is particularly convincing. The burden, then, is on the author to provide a more convincing explanation. Such a candidate is presented in the next chapter.

CHAPTER C4. A TECHNOLOGICAL THEORY

We cannot legitimately speak, for example, of 'the' elasticity of the demand for labour, for this will vary with every different kind of labour, almost with every firm, and with every different set of conditions. The responsiveness of employment of all building workers collectively to changes in wage-rates, for example, may be very high, whereas the responsiveness of employment of electrical installation workers alone to changes in their wage-rates may be very low, because the demand for electricians is a joint demand with that for other building workers.

Hazlitt (1959:271)

The explanations considered in the previous chapter all treat labour as a homogeneous input. While they could doubtless be adapted to a world with more than one type of labour, the essential logic of each argument works just as well without this complication. Such a treatment is not a natural fit to the literature in chapter C2, which deals with cases where particular groups of workers had their wages increased relative to other groups of workers - teenagers bound by the minimum wage versus adults who are not, women affected by equal pay laws versus men, etc. The employment effects were also measured in relative rather than absolute terms, or at least estimated with some overall measure of employment as a control, in most of the studies.

The puzzle, therefore, is not that the demand for labour as a whole is insensitive to wages, which is what all of the above explanations would imply. The puzzle is that the *relative* employment of particular groups of workers seems to be insensitive to *relative* wages. Stating the problem in such a way suggests an approach that emphasises the *heterogeneity* of labour.

Such an approach is presented in this chapter. The hypothesis is simply that the demand for labour becomes much less elastic when labour is disaggregated by occupation – that, as the above quote suggests, the demand for electricians is less elastic than the demand for building workers in general, which is in turn less elastic than the demand for labour as a whole. After a brief intuitive discussion, the argument is formalised in a ‘Leontief/Cobb-Douglas’ or ‘LCD’ production function, in which the labour input in a Cobb-Douglas function is a Leontief aggregate of workers in different occupations. While highly stylized, this function is presented as a useful first approximation, much like the ubiquitous Cobb-Douglas function itself. (More sophisticated and realistic extensions are presented in chapter C6.) The demand for labour derived from this function has the following properties: Employment in all occupations depends only on the average wage, so that relative wages do not affect labour demand. The own-wage elasticity of demand for labour in particular occupations is proportional to that occupation’s share in wage income, so that the more finely labour is disaggregated, the less elastic demand becomes. And workers in different occupations are complements, not substitutes, for each other. After these properties have been derived, some of the more obvious objections to the plausibility of the hypothesis are considered.

Intuition

The hypothesis of this chapter is that the nature of production technology makes the demand for labour in particular occupations quite inelastic, even if the demand for labour as a whole is not. Why might this be the case?

Modern economies rely on a complex division of labour. It may be difficult to change one part of a production process (e.g. to substitute capital for labour) without

making other, costly, changes elsewhere. A rise in wages representing a small share of total costs might not be a sufficient incentive to make such changes. If this is the case, the substitution as well as the scale effect of the wage change is likely to be small.

There is much anecdotal evidence that this is the case in modern economies, even with seemingly simple products. Mokyr (1990:114-115) generalises that 'Before 1850, technology consisted of more or less isolated chunks of knowledge in which sudden changes in production techniques could occur without dramatically affecting other industries or producers After 1850, the complexity of technological systems increased . . . in such systems certain components may resist change in other parts of the system because compatibility with existing techniques has to be satisfied.' He was anticipated by Marx (1887:ch.15, sec.1), who argued that 'A radical change in the mode of production in one sphere of industry involves a similar change in other spheres . . . Thus spinning by machinery made weaving by machinery a necessity, and both together made the mechanical and chemical revolutions that took place in bleaching, printing and dyeing imperative.' More recently, Dugger (2004) describes how the spread of supermarkets in Central America is forcing farmers to adopt more capital intensive techniques, such as greenhouses and drip irrigation, in order to deliver more homogeneous produce.

If such interdependency is an issue for textiles and vegetables, how much more must it be so with more complex products? To capture this intuition in mathematical form, and at the same time allow for capital-labour substitution in the aggregate, we adopt a functional form in which different types of labour are strongly complementary. (We will see in chapter C5 that this is also consistent with a wide range of empirical evidence.)

Begin with a Cobb-Douglas production function in labour and capital,

$$Y = L^\alpha K^{1-\alpha}.$$

Now, suppose that each unit of labour L is made up of a_i workers from each of $i = 1, \dots, n$ occupations. For example, in a string quartet of two violinists, a violist and a cellist, $n = 3$, $a_1 = 2$, and $a_2 = a_3 = 1$. Hence the value of L is a Leontief function of the number of workers L_i from each occupation:

$$L = \min \left\{ \frac{L_1}{a_1}, \dots, \frac{L_n}{a_n} \right\}.$$

Since there is no benefit from hiring more than the minimum necessary number of workers, the demand for labour in any occupation i is given by

$$L_i^D = a_i L^D \quad (\text{C.1})$$

$\forall i = 1, \dots, n$. L^D is the demand for aggregate labour units, given under perfect competition by the usual marginal product condition $Y_L = W$. W , the *average wage*, is the cost of a labour unit:

$$W = \sum_{i=1}^n a_i w_i, \quad (\text{C.2})$$

where w_i is the wage rate in occupation i . (All wages are in real terms throughout unless stated otherwise.) This implies

PROPOSITION 1: The demand for labour in all occupations depends only on the average wage, not on relative wages.

This is a straightforward consequence of equation (C.1), which gives labour demand in all occupations as a function of the (fixed) occupational demand coefficients a_i and

aggregate labour demand L^D . L^D is in turn a function of the average wage W , given the production function and capital stock. ‘Relative wages’ refers to the pattern of occupational wages, *given* the average wage W defined by equation (C.2). In other words, the average wage is a sufficient statistic for wages on the demand side.

PROPOSITION 2: The own-wage elasticity of demand in any occupation is proportional to that occupation’s share in total wage income.

Assume that wages are exogenously determined (e.g. through perfectly elastic labour supply or binding wage floors in all occupations). Consider a change in wages in one occupation, holding all other wages constant. The elasticity of demand for labour in occupation j with respect to the wage in occupation k , using the chain rule, is

$$\frac{w_k}{L_j^D} \frac{\partial L_j^D}{\partial w_k} = \frac{w_k}{L_j^D} \frac{\partial L_j^D}{\partial L^D} \frac{\partial L^D}{\partial W} \frac{\partial W}{\partial w_k}.$$

Denoting this quantity by E_{jk} , and using equations (C.1) and (C.2) to substitute for L_j^D and W , this becomes

$$E_{jk} = s_k E, \quad (C.3)$$

where

$$s_k = \frac{a_k w_k}{W} \quad (C.4)$$

is occupation k ’s share of wage income and

$$E = \frac{W}{L^D} \frac{\partial L^D}{\partial W} \quad (C.5)$$

is the elasticity of aggregate employment with respect to the average wage.²⁰ If the wage in occupation k is raised by one percent, holding all other wages constant, this

²⁰ The value of E depends on the behaviour of the capital stock. See Appendix 4.

raises the average wage by a percentage equal to occupation k 's share of wages. Employment in *all* occupations (the expression is independent of j) is reduced by this percentage multiplied by the elasticity of employment with respect to the average wage. The smaller an occupation's share of wages, the lower the own-wage elasticity it faces. In terms of the Hicks-Marshall laws of derived demand, E_{jk} is small because any one occupation has a small share in total costs, and the substitution of labour for capital only works at an aggregate level (i.e. it is very limited when considering occupations individually). The own-wage elasticity, of course, is just the case where $j=k$.

PROPOSITION 3a: Workers in different occupations are p-complements for each other.

It was shown above that increasing the wage in one occupation will increase the average wage and thus reduce the quantity of labour demanded in all other occupations. This argument is still valid if we hold output and the cost of capital constant, thus establishing p-complementarity.

An interesting corollary of this result is that, if we relax our initial assumption and suppose that wages in other occupations are *not* completely fixed (e.g. if labour supply is not infinitely elastic, or minimum wages do not bind everywhere), this reduction in demand will produce offsetting wage cuts in other occupations. Therefore, in equilibrium, the average wage will rise by less than s_k percent for each one percent rise in w_k , and the employment losses will be even less than suggested by equation (C.4).

PROPOSITION 3b: Workers in different occupations are q-complements for each other.

We now assume that there is an exogenous, perfectly inelastic supply of labour in each occupation, and show that, under these conditions, an increase in the number of workers in one occupation will tend to increase the wages in other occupations. This assumption means that demand will not equal supply in every occupation unless the relative supply across all occupations matches the fixed relative demands given by (C.1). The effective aggregate supply of labour – the maximum available number of labour units with the necessary workers from all occupations – is given by

$$L^S = \min \left\{ \frac{L_1^S}{a_1}, \dots, \frac{L_n^S}{a_n} \right\}. \quad (\text{C.6})$$

The limit to effective labour supply is given by those occupations for which $L_i^S = a_i L^S$. There may be anything from one to n of these ‘binding’ occupations. The remaining ‘surplus’ occupations for which $L_i^S > a_i L^S$ have a greater supply of labour than can possibly be employed.

Equilibrium employment and the average wage is obtained by setting $L^S = L^D$. But what is the equilibrium wage for each occupation? For the surplus occupations, the combination of excess and perfectly inelastic supply ($L_i^D = a_i L^D = a_i L^S < L_i^S$) would push wages down to some reservation level (for simplicity, zero). For the binding occupations ($L_i^D = L_i^S$), we have no further information that would allow us to determine their individual wages (unless there is only one binding occupation j , in which case $a_j w_j = W$). The marginal product of labour is no help, since it is discontinuous: an extra worker in any single occupation has a marginal product of zero, while reducing employment by one in any occupation reduces the effective labour input

by L/a_j and output by W/a_j .²¹ This must be larger than w_j unless j is the only occupation to receive a nonzero wage. All we know is that the weighted sum of their wages, given by (C.2), must equal the equilibrium average wage given by $L^S = L^D$. Relative wages for the binding occupations are indeterminate.

Now we may answer the original question: What will happen to wages if the supply of labour in one or more occupations is increased? The answer depends on which set of occupations is affected. If labour supply increases in the surplus occupations, the effective labour supply given by (C.6) is not affected and there is no change in anything aside from unemployment. If the increase is only in some subset of the binding occupations, these will be converted into surplus occupations. Again, there is no change in the effective labour supply, employment or the average wage. But assuming that wages fall in the occupations which have been converted from binding to surplus (i.e. assuming they were paid above reservation wages to begin with), wages in the remaining binding occupations must rise in order for the average to remain unchanged. Finally, if labour supply rises in *all* binding occupations, this will increase effective labour supply and employment, and thus reduce the average wage. However, it will still increase wages in the initial surplus occupations if the increase in employment turns some of them into binding occupations.

The effect of a wage floor under these assumptions would also vary depending on the occupations affected. As long as there are binding occupations not bound by the floor, these workers would absorb as wage cuts the others' wage rises, since the average wage must remain unchanged to maintain the equilibrium condition $L^S = L^D$. But once all binding occupations are affected by the floor, then employment is demand

²¹ Recall that the marginal product of labour in this case is derived holding *employment* in other occupations constant, while the smooth labour demand curve underlying (C.4) is derived holding *wages* in other occupations constant.

constrained rather than supply constrained. Further increases in the wage floor will increase the average wage and reduce employment according to the average wage elasticity E .

Objections

The LCD function is effectively a special case of the two-level constant elasticity of substitution (CES) function first described by Sato (1967). The elasticity of substitution between labour and capital is one, giving the Cobb-Douglas part of the function, and the elasticity of substitution between the different components of the labour aggregate is zero, the Leontief component.

While the use of CES functions to aggregate different types of labour is routine, the assumption of zero substitution between types is not.²² However, the identification strategies used to generate these elasticities generally do not include exogenous wage shocks. (When they do, we get the results in chapter C2.) Furthermore, workers in these studies tend to be classed by personal characteristics, such as age, sex, and years of education, rather than the type of work they are doing, as is done here. There is only a small literature on the elasticity of substitution between different occupations. Unfortunately, it is rather dated, relies on implausible identifying assumptions (again, not including wage shocks), and gives a wild range of results. See Hamermesh (1993:108-118) who does not include any of its findings in his end of chapter summary of 'Things We Know'.

Why disaggregate by occupation in the first place? Classifying by personal characteristics may be appropriate if one is interested in measuring the effect of immigration, equal pay legislation, or education on wages and employment. It is not

²² See Hamermesh (1993), and more recently the immigration literature following Borjas (2003).

necessarily suitable when considering the effect of governments or unions altering the wage structure. Collectively bargained or legislated wages tend to be specified as a rate for the job rather than as a function of the characteristics of the individual worker.²³ This type of disaggregation also seems fundamentally more satisfactory as a realistic description of production: why should the sex or age, or even the education, of the worker matter if they are doing the same job? Employers advertise for accountants, nurses, waiters etc, not generic workers of a particular age and education. Conversely, workers in different occupations – say doctors, engineers and lawyers – are not anything like perfect substitutes for each other simply because they are in the same age/education cell. Furthermore, if a worker switches jobs, it makes sense that their contribution in the production function should be reclassified to reflect this.

Disaggregating by occupation rather than personal characteristics might plausibly reduce the ease of substitution between different types of labour. It certainly eliminates the simplest method, which is to have a different worker do the same job. As Neumark and Wascher (2008:62) state, ‘the substitution by employers away from lower-skilled minimum wage workers towards higher-skilled, higher-wage workers is likely the principal source of disemployment effects of minimum wages.’ This would be the case if, say, an employer replaced a teenage worker with an adult as the result of a minimum wage law. There has been a substitution of one worker for another, but from an occupational point of view employment has not changed as long as the same work is being performed.

One might argue that, even if the LCD function is a reasonable representation of a particular industry, aggregation issues could make it a poor model of the economy as a

²³ At first glance equal pay legislation would seem to contradict this. However, occupations are to a large degree segregated by sex. Gregory and Duncan (1981) found that in 1978, 83 percent of Australian female workers were in occupations where the ratio of females to males was greater than in the workforce as a whole, a statistic that had changed little since 1911. The equal pay decision was significant because it raised the pay of female dominated occupations – “equal pay for work of equal value”.

whole. But if it is admitted, for the moment, that it can be used for a representative industry, then two conditions must hold to make it inapplicable at a macro level. There must be both (a) large differences in the composition of labour demand across the different industries, and (b) a large amount of substitution between the products of different industries.

To see why, consider the following thought experiments. If different industries employ workers from different occupations, but the relative demand for their products is inelastic, then a rise of wages in one occupation will simply be passed on in the product price, without affecting employment. One group's wage rise is everybody else's wage cut. If, conversely, each industry uses workers from much the same occupations, then it does not matter if product demand is very elastic, since every industry will be affected equally if a particular occupation enjoys a rise in wages. Only if each industry has a highly unique employment pattern *and* elastic product demand will an increase in wages for one occupation flow through to lower production in particular industries which use that occupation intensively, and hence to lower employment in that occupation relative to others.

Now, while there are many plausible situations in which (a) or (b) might be true, it is more challenging to argue that both are true simultaneously. In particular, the more finely different industries are disaggregated, the more likely it is that (b) is true, as the elasticity of demand for broad product groups is generally lower than that for specific, branded products (Clements 2007), but the less likely it is that (a) is true, as one would assume that the more similar the products are, the more similar the technology. This issue is considered further in chapter C6.

Alternatively, the function may be a reasonable approximation of the macroeconomy without being accurate for any particular industry. The well known

Baumol effect states that the relative price of labour intensive goods rises with income. For example, the price of consumption goods relative to investment goods tends to be higher in countries with higher income levels (Restuccia and Urrutia 2001). When combined with the fact that these labour intensive goods and services are still a large and even rising share of expenditure and employment as incomes rise, this may be an indication that there are large chunks of modern economies which still have very limited substitution of capital for labour. Imbs and Wacziarg (2003) and Hidalgo et al (2007) demonstrate that rich countries produce a different, more diverse range of products than poor countries, rather than simply producing homogeneous output with more capital intensive technology. This could further limit substitution possibilities in response to a wage shock. It should also be noted that the simplification in this model is not all in one direction: the Cobb-Douglas assumption of unit elasticity of substitution between capital and aggregate labour is probably an *overestimate* (Andersen, Klau & Yngaard 1999).

Finally, it may be argued that international trade makes purely national wage setting ineffective. If domestic wages in tradable industries are set too high, they will be undercut by import competition. While this has some force, the general consensus is that trade has had only a small effect on inequality in developed countries (see chapter A3). Certainly the forces of globalisation have not prevented countries within the OECD from having very different wage setting institutions and patterns of inequality, without obvious employment penalties. If wage setting institutions mainly affect relative rather than average wages, then total costs should not be much affected and there is little incentive to move production offshore. It has also been suggested that trade with low-wage countries is just not big enough relative to the size of developed

economies to have a large effect on their wages. Whatever the reason, the law of one price is generally not seen as applying fully in global labour markets (Leamer 2007).

Summary

This chapter has presented an alternative hypothesis for the empirical puzzle in chapter C2: that the demand for labour is much less elastic at the level of the individual occupation than it is at the aggregate level. This argument is formalised in a ‘Leontief/Cobb-Douglas’ production function, in which different occupations are perfect complements for each other, implying that relative wages have no effect on employment. This admittedly stylized function is presented as a reasonable first approximation to reality, even when considering potential issues arising from aggregation and trade. We next consider how well it matches other features of the labour market, compared to the alternatives considered in chapter C3.

Appendix: Labour demand elasticities with Cobb-Douglas production

The elasticity of demand for labour depends not only on the production technology, but also on the assumptions made about the supply of other factors of production. Some possibilities for $E = \frac{W}{L^D} \frac{\partial L^D}{\partial W}$, the elasticity of labour demand with respect to the average wage, under the assumption of a Cobb-Douglas production function in labour and capital, are:

Case 1: A competitive industry facing a given product demand function and constant cost of capital. As shown in chapter B1, Allen (1938:372-3) gives the elasticity $E = s\eta - (1-s)\sigma$, where W is the nominal wage, s is the labour share of income, σ is the

elasticity of substitution between capital and labour, and η is the (negative) own-price elasticity of product demand. Since $s = \alpha$ and $\sigma = 1$ in a Cobb-Douglas function, this expression reduces to $\alpha\eta - (1 - \alpha)$. The first term is the scale effect (a rise of 1% in the nominal wage means a $s\%$ rise in the product price and a $s\eta\%$ fall in product demand) and the second the substitution effect, which can also be interpreted as a constant output elasticity. This reasoning is not, however, really applicable in a macroeconomic context, unless we have a country specializing in a single product for which it has some degree of market power.

The above equation may also be considered as a real wage elasticity if the real wage is measured with respect to consumer goods, and the product of the industry in question is an infinitesimal part of the consumption bundle. For the producer real wage elasticity, simply divide by the percentage change in the product price (the elasticity of price with respect to the wage) $s = \alpha$.

Case 2: Constant capital stock. The standard assumption for the short run in a macroeconomic model – see chapter B2 for the contrast between this case and case 3.

The labour demand function is $L^D = K \left(\frac{\alpha}{W} \right)^{\frac{1}{1-\alpha}}$ implying $E = \frac{-1}{(1-\alpha)}$.

Case 3: Solow-Swan steady state or a small economy with perfect capital mobility.

Either assumption fixes the return on capital and the capital-labour ratio. The average wage is then endogenous – i.e. the elasticity of demand is infinite. (This result is not specific to a Cobb-Douglas function – it holds for any nonzero rate of substitution between capital and labour.) Changes in relative wages simply redistribute income

between groups. A long run wage rise in one occupation is only possible if it forces wage cuts in other occupations, as is the case with inelastic labour supply.

CHAPTER C5. THEORIES VS. STYLIZED FACTS

So far, we have seen a large amount of empirical evidence that the demand for labour is insensitive to relative wages. We have argued that the most common explanations for this observed insensitivity – mismeasurement, monopsony, efficiency wages, and aggregate demand – are unconvincing. And we have suggested an alternative hypothesis: that the nature of production technology makes the demand for labour in individual occupations (i.e. the demand for workers in particular jobs) inelastic.

We now present a number of stylized facts about the labour market, which strengthen the case for the technology-based explanation versus the leading alternatives: mismeasurement, monopsony, efficiency wages, and aggregate demand. This exercise is not intended to disparage these theories in general: they may be perfectly valid explanations for other important phenomena in the labour market. The aim is merely to argue that they are inadequate to explain the observed insensitivity of employment to relative wages. The findings are summarised in Table C.3 at the end of this chapter.

STYLIZED FACT 1: There is a robust empirical tradeoff between average wages and employment.

Contrary to the situation with relative wages, this tradeoff is well documented in Hamermesh (1993) and is a standard finding in empirical macroeconomics. Since the LCD function is a standard Cobb-Douglas function as far as aggregate employment is concerned, this is exactly what it predicts.

What about the other candidates? Manning (2003) argues that this fact is compatible with monopsony as long as the variation in wages is driven by labour supply (rather than institutional) shocks. While this is a valid theoretical point, it is hard to believe that the variation in wages in the data is dominated by this in periods when unemployment has been high and institutional factors have also been important in shaping wages. In particular, Gregory's (1995) comparison of the US and Australia, which shows a lack of connection between *relative* wages and employment, also shows a textbook relationship between *average* wages and employment at a time of rising unemployment and (in Australia) high nominal wage growth and industrial strikes. It also provides a useful corrective to arguments that adjustment lags or the small size of wage shocks make it impossible to identify employment effects.

The efficiency/effort and aggregate demand theories provide no explanation for this fact. Indeed, the aggregate demand theory really implies the reverse: it is a theory of why average wages do *not* affect employment at the macroeconomic level (or might even have a positive effect), and is perfectly compatible with relative wages affecting the employment of smaller groups of workers: 'a special reduction of money-wages is always advantageous to an individual entrepreneur or industry' (Keynes 1936: ch.19). The mismeasurement theory would be compatible with this fact, if for some reason, the signal/noise ratio was better for average wage data. However, the converse seems more plausible: as emphasised in section 2, the relative wage literature covers some quite large shocks. It would be hard to find comparably sized, plausibly exogenous changes to average wages, let alone ones that are significantly larger.

STYLIZED FACT 2: Strong labour market institutions are robustly correlated with lower wage inequality, but not with higher wage shares.

In the words of Durlauf and Blume (2008), ‘virtually all analyses find that labour institutions reduce the dispersion of hourly earnings and the inequality of income.’ There is no such consensus, however, on the effect of these institutions on the share of wages in the total product. The recent trend has been for the less regulated Anglophone economies to experience rising wage inequality and small falls in wage shares, while the more regulated Europeans (and Japanese) have seen stable wage inequality but large falls in wage shares.

These results, amply illustrated in chapter A4, are confirmed in Tables C.1 and C.2, which show some simple regressions of wage inequality and the wage share on collective bargaining coverage and minimum wages. The same data set of 10 OECD countries from 1975-2007 is used (described in further detail in the Data Appendix to Part A). It can be seen that both collective bargaining coverage and the minimum wage are negatively correlated with wage inequality regardless of the inclusion of year and country fixed effects, and even the size of the coefficients are reasonably consistent. Even when both variables are included together (not shown), at least one and sometimes both are statistically significant, which is surprising given that the two variables are highly correlated and potential substitutes for each other. On the other hand, Table C.2 shows that these institutions are more often than not correlated with *lower* wage shares. The exception is when country fixed effects but not year fixed effects are included, reflecting the fact that, on average, both wage shares and institutions have declined over the relevant period. Of course, these regressions have potential problems with omitted variables and endogeneity, but they certainly shift the burden of proof onto those who would argue that these institutions have a strong positive effect on the wage share.

Table C.1.a: Regressions of wage inequality on collective bargaining.

Dependent variable: 9/1 earnings decile ratio				
Collective bargaining	-0.0158*** (14.5)	-0.0153*** (13.8)	-.0108*** (8.97)	-0.00810*** (7.58)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	305	305	305	305
Countries	10	10	10	10

Table C.1.b: Regressions of wage inequality on minimum wages.

Dependent variable: 9/1 earnings decile ratio				
Minimum wage	-2.71*** (7.18)	-2.63*** (6.29)	-3.69*** (11.7)	-3.23*** (10.6)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	175	175	175	175
Countries	6	6	6	6

Table C.2.a: Regressions of wage shares on collective bargaining.

Dependent variable: wage share				
Collective bargaining	-0.0503*** (4.99)	-0.0582*** (7.40)	0.0033 (0.16)	-0.0431*** (3.72)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	356	356	356	356
Countries	10	10	10	10

Table C.2.b: Regressions of wage shares on minimum wages.

Dependent variable: wage share				
Minimum wage	-25.7*** (6.74)	-25.5*** (8.56)	12.1** (2.11)	-11.4*** (3.62)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	183	183	183	183
Countries	6	6	6	6

Data used as in Chapter A.4 & Data Appendix to Part A.

T-statistics in brackets. ***, **, * indicate 1%, 5%, 10% significance levels respectively.

Constants estimated but not reported for models with no FE.

As shown in chapter A4, the inclusion of many other potentially relevant variables does not disturb the above results: higher collective bargaining coverage is robustly correlated with lower wage inequality (although as a time interaction rather than levels), but not with higher wage shares (again the estimates are mostly negative, although often insignificant).

These results are largely consistent with the LCD function, which allows institutional wage setting to alter the distribution of wages, but not change the wage share, which is a fixed parameter in the production function. (If we take the Cobb-Douglas part of the LCD function less seriously and allow for an elasticity of substitution different from one, then there is no particular prediction for the effect on the wage share.) They present a challenge to the monopsony, efficiency wage, and aggregate demand theories, in which there is a rent or surplus to the employment relationship that is up for grabs between employer and employee. A binding wage floor should redistribute income between wages and profits, particularly if it applies to the whole economy. One might also speculate that a general strengthening of the bargaining power of employees, as opposed to a simple wage floor, would not necessarily reduce inequality. Both efficiency wage and monopsony considerations seem more, not less relevant, to more highly paid and specialised labour.

In fact, any explanation which works with homogenous labour must be suspect given this fact. The combination of a higher wage and no employment loss implies higher wage income, while profits must be lowered (since employers did not find it profitable to pay higher wages without regulation). Even if there is some general equilibrium effect (e.g. from increased output) which offsets the *absolute* decline in profits, it would have to be large indeed to prevent a decline in the profit (and rise in the wage) *share*. The mismeasurement theory is not inconsistent with this observation, but does not provide an explanation for it either.

STYLIZED FACT 3: Centralised or coordinated bargaining can moderate wage demands by unions.

Imagine a society with a perfect division of labor. That means perfect interdependence: every single member's contribution of capital or labor is essential if there is to be any production at all, so every member has an individual capacity to stop the whole productive machine The asking-prices will inevitably add up to more than the total that the machine can produce If the contenders have equal capacities to hold out . . . they will eventually agree, just before they all starve to death simultaneously, to work for exactly equal rewards.

Stretton (1976: 244-245)

Various hypotheses have been advanced regarding the relationship between collective bargaining institutions and macroeconomic performance (particularly unemployment and inflation): It has been argued that more centralised or coordinated systems produce better outcomes, that there is a U-shaped relationship (with the extremes of de/centralisation doing better than the middle ground), or even that there is no relationship once the effects of international trade are taken into account. As summarised in Flanagan (1999), the evidence is ambiguous. Rankings of centralisation and coordination (the distinction is between the formal legal structure and actual behaviour) are subjective and ordinal, so that the empirical results are fragile to the classification used as well as the time period. Significantly, however, no-one has put forward the theory that more centralised or coordinated systems do systematically worse, in the sense that they are *less* conducive to wage restraint and thus produce higher inflation and/or unemployment.

The Appendix to this chapter describes a simple wage bargaining game using the LDC function. Intuitively, the larger the number of unions bargaining independently,

the less elastic the demand for labour they each face, and the higher the wages that they set, without regard for the damage this does to employment in other occupations.

None of the other theories gives a clear reason as to why this would happen. If the demand for labour in the aggregate was in fact less elastic than the demand for labour in particular occupations or industries, there would be little reason to worry about this problem. We would instead have a literature complaining about how unions compete in undercutting each other, and calling for coordination to boost wages, not moderate them.

STYLIZED FACT 4: Immigration (or a native underclass) can increase the average wages of native workers, yet workers still resist increases in labour supply in their own occupations.

Our wages paid to skilled workers in South Africa are far in excess of what are paid in any other country except America and we were [sic] able to do it because we paid the black man such a low wage.

Jan Smuts, Prime Minister of South Africa (Lipton 1985: 176).

Workers want their own work to be rewarded with high wages. But they are also happy to see other's work rewarded with low wages, *as long as their own jobs are not threatened by this*. One extreme historical example is Germany in the Second World War, when approximately 30% of the industrial and agricultural workforce was foreign: 'The arrival of a huge class of people in Germany who were by definition inferior to the lowest German was plainly of benefit. . . . The lowly German worker could become a foreman; the housewife could have servants.' (Rees 2005:334.) Another is apartheid in South Africa, where white unions helped create and enforce a complex set of rules governing entry into particular occupations by race. Mariotti (2009) describes how

these rules were manipulated to ensure the maximum benefit for white workers: as their educational levels increased and they moved into more skilled jobs, the restrictions on Africans in semi-skilled occupations were relaxed. The general principle is the same wherever there is an immigrant or native underclass that is tolerated or even valued as long as they keep their place, doing jobs the other citizens do not want. Other examples can be seen in the many caste systems that have existed since antiquity, the United States during Jim Crow, or indeed post-war migration into Australia, in which highly qualified professionals were forced to work as manual labourers. At the other end of the spectrum, Friedman and Kuznets (1954) argued that doctors' income was boosted by the restriction of entry into the profession.

Even without such rigid controls, recent analysis of immigration tends to find that it does not harm the average wage of native workers,²⁴ and even the relative wages of similar native workers are not too badly affected (see chapter B2). It is interesting to note that, while their estimates of wage effects are based on personal characteristics (education and experience), Ottaviano and Peri (2005:12-13) explain their findings with reference to the concentration of immigrants in particular occupations: 'foreign born workers are highly represented in occupations like tailoring (where 54% were foreign born in 2000) and plaster-stucco masonry (where 44% were foreign-born in 2000), while U.S.-born workers are highly represented among, say, crane operators (where less than 1% was foreign-born in 2000) and sewer-pipe cleaners (where less than 1% [were] foreign-born).'

The key point is not just that labour supply can be increased without hurting the incumbent workers, or even that there exists a certain amount of complementarity between different types of workers (which is practically automatic if the average wage

²⁴ At least when it is a one-off level shock and not an increase in the growth rate of the labour force.

is fixed in equilibrium, as seen below in chapter C6). These facts are perfectly compatible with a demand for labour that is highly elastic at all levels.²⁵ It is the combination of these facts with the almost universal impulse to keep the new workers in their place, to resist an increase in labour supply within particular lines of work.

This fits perfectly with the LCD function's properties of complementarity *between* occupations and inelastic demand *within* occupations. Conversely, if the demand for labour in particular occupations was elastic, there would be little incentive to restrict entry, since employment could rise to absorb an increase in labour supply without much of a wage penalty. This would be true even in a monopsony or efficiency wage setting. Furthermore, if workers in one occupation were generally good substitutes (rather than complements) for workers in other occupations, low wage labour even confined to particular jobs would be a threat rather than a benefit to other workers. If employment is limited by aggregate demand, on the other hand, one might have an argument for why native workers would resist a general increase in labour supply (assuming for the moment that the newcomers would not increase demand as well), but not for why there should be such a stark contrast in the within- and between- occupation effects.

²⁵ David Card's minimum wage and immigration research might seem somewhat incongruous, the one seemingly implying an inelastic demand for labour (minimum wages do not reduce employment) and the other an elastic demand (immigration does not reduce native wages). These findings, however, are not necessarily contradictory. They could be explained by a monopsony model of the labour market with a constant marginal product of labour, for example. Of course, this essay argues that the monopsony explanation is lacking for other reasons, and that the technological hypothesis is to be preferred.

STYLIZED FACT 5: When unemployment is low, employers and policymakers complain of skills shortages. When unemployment is high, they complain of structural unemployment.

While skills shortages and structural unemployment have not received a lot of attention from academic economists in recent decades, the concepts have a long history and are used regularly in more practical discourse (Hoque and Inder 1991, Morissette and Salvas-Bronsard 1993, Ohtake 2004).²⁶ The idea that the economy needs a supply of workers with the right skills in the right proportions and the right locations is apparently quite robust. In good times, a shortage of particular types of workers is seen as a brake on the entire economy, to be met with selective immigration and focused training efforts (Richardson 2007). In bad times, worries arise that unemployment is not due merely to insufficient aggregate demand or excessive wages, which are relatively simple (if not always easy) to diagnose and treat, but to a more intractable mismatch between the skills and geographic location of the labour force and potential employment opportunities.

Although these concepts make intuitive sense, indeed seem somewhat obvious, it is worth reflecting on the conditions necessary for them to be valid. If a shortage of a particular kind of worker can have consequences for the whole economy, both employers and other types of workers, that implies both a certain amount of inelasticity in the demand for that type of worker, and a certain amount of complementarity with other occupations. The LCD function is a perfect illustration of these properties. Indeed, it enables a more rigorous definition of the terms to be given. Structural unemployment may be defined as the number of workers in the surplus occupations, as

²⁶ 'Structural unemployment' now tends to be used merely as a synonym for the NAIRU. See e.g. Backhouse (1997) for the original use of the term.

defined in chapter C2. Skills shortages may be defined as the number of extra workers needed in the binding occupations to convert them to surplus occupations.

Without these properties, however, both terms become almost meaningless. For clarity, consider the opposite extreme, where the demand for all kinds of labour is infinitely elastic. Employers will happily hire as many workers as present themselves, but do not gain economic surplus from a higher level of employment, and there is no obvious reason to label a low supply of workers as a shortage. Wages may be high or low in a particular line of work, but this is of little concern to anyone except the workers themselves. Structural unemployment is almost an impossibility: as long as *some* workers of a certain type are employed, it is possible to expand that employment infinitely at the same wage.

Conditions of monopsony or efficiency wages require some modification to this statement, but do not invalidate the main point. Shortages may be said to exist under monopsony, in that employers would be willing to expand employment if they did not have to simultaneously raise wages, or in the sense that inefficiently low wages may cause inefficiently low investment in human capital. Some efficiency wage theories predict equilibrium unemployment (e.g. the Shapiro-Stiglitz model). Yet these phenomena do not correspond to our concepts of structural unemployment and skills shortages. The unemployment under efficiency wages is not the result of there being 'too many' workers of a particular kind, but of other considerations such as the efficiency of monitoring technology and the disutility of effort. And as long as the marginal productivity of labour is insensitive to the level of employment, the 'shortages' under monopsony seem unlikely have the kind of economy-wide or surplus-destroying effects attached to the concept of a skills shortage. Similarly, the aggregate

demand theory, on its own, provides no explanation for why some occupations would be more affected by unemployment than others.

Summary

As well as predicting that employment is insensitive to relative wages, the technological theory presented here is also consistent with a range of stylized facts about the labour market: the elasticity of employment with respect to average wages, the correlation between strong labour market institutions and lower wage inequality, and the *lack* of such a correlation between institutions and wage shares; the moderating effect of coordination on centrally bargained wages, the contrasting reaction of workers to labour supply inside and outside their own occupations, and the existence of skills shortages and structural unemployment. The competing explanations – mismeasurement, monopsony, efficiency wages and aggregate demand – are often inconsistent with and generally do not predict these facts, as summarised in Table C.3. This is strong, albeit indirect, evidence in favour of the technological explanation.

The common theme in many of these situations is the distinction between aggregate labour and average wages on the one hand, and particular occupations and relative wages on the other. As argued above, this distinction is at the core of the technological explanation, but plays no part in any of the others.

Table C.3: Summary of Theories vs. Stylized Facts.

	Evidence	Technology	Mismeasurement	Monopsony	Efficiency wage	Aggregate demand
1. Effect of average wage on employment	-ve, larger than relative wage effect	-ve, larger than relative wage effect	No different from relative wage effect			Smaller than relative wage effect (or +ve)
2. Effect of institutions on wage shares & inequality	Little effect (possibly -ve) on shares, reduce inequality	No effect on shares, reduce inequality	Depends on elasticity of substitution	Increase wage share, inequality ?		
3. Effect of coordinated wage bargaining	Moderates wage demands (or no effect)	Moderates wage demands	No effect or increased demands			Increased demands
4. Effect of increased labour supply	Bad for similar workers, good for others	Bad for similar workers, good for others	Small effect, little difference between similar workers & others			
5. Skills shortages & structural unemployment	Exist often	Well defined, exist almost always	Generally ill-defined, shouldn't exist (see discussion of skills shortages under monopsony)			

In order to distinguish between technology and the other theories, the others are presented under the assumption that the demand for labour in particular occupations with respect to their relative wages is equally or more elastic than the demand for labour with respect to the average wage.

Appendix: Collective bargaining and the LCD function

Suppose that all wages are set by a single monopoly union, which maximises wage income WL subject to aggregate labour demand L^D . If L^D is elastic, this union will set the average wage to employ as many workers as possible, i.e. pursue full employment (or the fullest possible given mismatches between supply and demand across occupations). This means the same average wage and employment as in a competitive situation. Relative wages, however, can be anything the union wants (assuming it has sufficient control over labour supply). If demand is inelastic for some relevant values of the average wage, the equilibrium will be at the top of this range, again with any desired pattern of relative wages.

Now, break up the monopoly union into n parts, one for each occupation.²⁷ Assume that each union plays a simultaneous wage setting game with an unlimited supply of labour. The union for occupation j maximises $w_j L_j^D$ with respect to w_j , yielding the first order condition

$$L_j^D (1 + E_{jj}) = 0, \quad (C.7)$$

where $E_{jj} = s_j E$ is the own-wage case of equation (C.3). This implies that $s_j E = 1$. Each union will target a share of labour income equal to the inverse of the elasticity of demand for labour with respect to the average wage. Unions with a smaller share in employment (as measured by the a coefficients) will set higher wages to achieve this. Equilibrium can only exist if the total wage demands add up to the average wage, which is not always possible.

²⁷ It would be possible to have some unions covering more than one occupation. Nothing in the discussion below would change, except that n would have to be replaced by a smaller number and the a 's combined for the multi-occupational unions. However, since each union targets an equal share of wages irrespective of size, there would be little incentive for unions to amalgamate.

For example, if the capital stock is fixed (see the appendix to chapter C4, Case 2) then $E = (1 - \alpha)^{-1}$ and each union will target a $(1 - \alpha)$ share of labour income. If $n = (1 - \alpha)^{-1}$, there can be an equilibrium at any average wage, with no reference to the capital stock. If the number of unions is smaller than this, their wage demands will add up to less than the average wage. Their share in wage income is sufficiently large that each union will have more to gain by cutting their wage to increase employment rather than raising wages to increase their share. However, the supply of labour would eventually be limited in some occupation or another. At this point, since employment cannot increase further, there is no gain to any union from cutting wages further. As long as each union has at least their target share of the average wage, there is no incentive for any union to raise their wage either. So there is an equilibrium with a determinate average wage and employment (the same as under centralised bargaining or perfect competition), and a floor under each union's share of wages, but with an indeterminate distribution of the excess $(1 - n[1 - \alpha])$ share.

If the number of unions is larger than the critical value, however, total wage demands will always add up to more than the average wage. If it is legitimate to use the result of a one-shot simultaneous move game as insight into a dynamic process, one could imagine a continuing upward spiral of wages as each union tries to leapfrog the others.

This 'knife-edge' result is, of course, dependent on the exact LCD functional form (both the zero substitution between different types of labour and an elasticity of unity between aggregate labour and capital), a constant capital stock, unions maximising income only, and the game being one-off rather than repeated. The main

point, which does *not* depend on these exact assumptions, is simply that smaller unions face less elastic demand and therefore have an incentive to set higher wages.

A similar argument has often been made with respect to inflation – that centralised bargaining internalises the welfare effects of the price rises that follow an increase in wages. The above is really just a recasting of this argument in real terms. The assumption that rising wages *in particular occupations or sectors* mainly drive up prices, instead of destroying employment, implies an inelastic demand for labour.

CHAPTER C6. EXTENSIONS OF THE LCD

FUNCTION

The Leontief/Cobb-Douglas specification used in chapter C4 is highly stylized, as are the canonical production functions it is based on. It is employed as the simplest method of deriving the desired properties in a mathematically consistent way. However, this should not be taken to mean that the most extreme assumptions, particularly that of zero substitution between different types of labour, are necessary to give the desired results. In this chapter we relax several of the assumptions of the LCD function to create richer and more realistic models that still preserve its essential properties. Firstly, we allow for substitution between different goods and different types of labour. Secondly, we allow for capital-skill complementarity, removing the symmetry between different types of labour. Finally, we allow skill levels and productivity to vary among workers within each occupation.

Multiple goods & nonzero substitution

Consider a model economy in which a number of different goods are produced using capital and labour, with constant elasticity of substitution (CES) production technology. Further suppose that the labour input is itself a CES aggregate of different types of labour. Therefore, for each industry we have the production function

$$Y = (\alpha_L L^\rho + \alpha_K K^\rho)^{1/\rho}, \quad (\text{C.8})$$

omitting subscripts since we will only deal with one industry at a time. Furthermore, the labour input is given by

$$L = \left(\sum_{i=1}^n a_i L_i^\delta \right)^{1/\delta} \quad (\text{C.9})$$

where, as in the LCD function of chapter C4, L_i indicates the amount of labour from each different occupation $i=1, \dots, n$. The elasticity of substitution between capital and labour is $\sigma = (1 - \rho)^{-1}$, and similarly the elasticity of substitution between different types of labour is $\theta = (1 - \delta)^{-1}$.

Change in wages in one industry. We now derive the own-wage elasticity of demand for any particular occupation, under the assumption that it is a microeconomic situation best modelled in terms of the elasticity of product demand and a constant cost (i.e. infinitely elastic supply) of capital. This is done simply by iterating the elasticity equation from case 1 of the Appendix to chapter C4. In the first iteration, we find E_{jj} , the own-wage elasticity of demand for occupation j , in terms of its share in wage income s_j , the elasticity of substitution between it and other types of labour, θ , and E , the elasticity of demand for the aggregate labour input L with respect to the average

$$\text{wage } W = \frac{1}{L} \sum_{i=1}^n w_i L_i :$$

$$E_{jj} = s_j E - (1 - s_j) \theta . \quad (\text{C.10})$$

A one percent rise in the wage of occupation j will raise the average wage by s_j percent and thus reduce the demand for all types of labour by $s_j E$. It will also create a substitution effect equal to the elasticity of substitution between different types of labour multiplied by the share of all occupations other than j in total wages. In other words, E_{jj} is a linear combination of the elasticity of demand for the labour aggregate and the elasticity of substitution between different types of labour, converging to the

first as s_j approaches one, and to the second as s_j approaches zero. Clearly the demand for any occupation j will become more elastic as s_j rises, as long as $\theta + E < 0$. In other words, if the absolute value of the elasticity of demand for the labour aggregate is greater than the elasticity of substitution between different types of labour within that aggregate. This seems plausible enough, as long as the demand for aggregate labour is fairly elastic, and the elasticity of substitution between different types of labour is low.

In the second iteration, we can simply substitute for E in (C.10) using the same equation, which yields

$$E_{jj} = s_j [s\eta - (1-s)\sigma] - (1-s_j)\theta, \quad (\text{C.11})$$

where, in the standard notation, s is the labour share in total income, σ is the elasticity of substitution between capital and labour, and η is the elasticity of product demand.

At this point, it is useful to introduce some plausible parameter values. These are shown in Table C.4. η and σ are average values from reviews of the literature on each subject, while typical values of s are taken from Part A of this thesis. θ , the elasticity of substitution between different types of labour, is obviously more contentious. The given values are for male and female labour (Gregory and Duncan 1981), and a finer disaggregation also including age and education (Card, Kramarz and Lemieux 1999). One may see them simply as plausible values that are low, but mostly greater than zero.

If we apply these values, it is simple to see that an occupation which accounts for a negligible share of labour costs in its industry would face an own-wage demand elasticity given by $-\theta$, which ranges between 0 and -0.3. At the other extreme, workers for the industry as a whole would face an elasticity of $E = s\eta - (1-s)\sigma$. The parameter values in Table C.4 yield values for E between -0.46 and -0.88. Not only does demand become more elastic as the share of labour costs increases, but the value for the whole

Table C.4: Parameter values for equation (C.11).

Parameter	Value	Source
η	-0.5	Clements (2007) ²⁸
	-1	Anderson et al (1997:59)
σ	0.4-0.6	Chirinko (2008)
s	0.6-0.7	Part A (Figure A.2)
θ	0.3	Gregory and Duncan (1981)
	0-0.16	Card, Kramarz and Lemieux (1999)

industry is still quite inelastic. This shows that, even after introducing realistic amounts of substitution both between different goods, and different types of labour in the production of those goods, labour demand can be inelastic for significant groups of workers. Note also that this is the most unfavourable situation for our hypothesis given the discussion in chapter C4: the increase in wages affects one industry only, maximising the potential for substitution with other products.

As an aside, the cross-wage elasticity of demand for any other occupation k with respect to w_j is

$$E_{kj} = s_j(E + \theta) \tag{C.12}$$

(Hamermesh 1993: 35). The scale effect is the same as for the own-wage elasticity, but the substitution effect is positive. Based on the values calculated above, the first will outweigh the second, so that an increase in the wage in one occupation will reduce the demand for workers in other occupations. In this loose sense we may say that the occupations are still complements. Technically, however, p-complementarity usually refers to constant output elasticities. In this case we would have to use the constant output version of $E = -(1 - s)\sigma$. Using Table C.4, E would be between -0.24 and -0.12, so that E_{kj} could be positive for some values of θ . However, the looser sense used above

²⁸ Technically, these are compensated and Frisch elasticities, rather than the ordinary (Marshallian) elasticity required by equation (C.11). However, the difference is only a matter of the expenditure share of the good in question. In any case, the bias is towards zero, and we consider -1 as an alternate value. It should also be noted that this value is an average for broad product groups (e.g. food), not specific commodities or branded products.

seems more practically relevant, if one is wondering whether an increase in wages in one occupation is good or bad for workers in other occupations.

Change in wages in all industries. To calculate the effect of a wage change in more than one industry in general equilibrium would require far more information and/or assumptions about the production technology used in the different industries, the degree of substitution between their products, and the elasticity of supply of the factors of production (the microeconomic assumptions of the above exercise no longer being appropriate). As a simple illustration, consider the case when all industries have the same technology, allowing (C.8) and (C.9) to be a representative production function for the entire economy. Assume further that in the long run equilibrium, the average wage is constant (see the appendix to chapter A4), and there are only two types of labour, skilled and unskilled, so that (C.9) becomes

$$L = (S^\delta + U^\delta)^{1/\delta}. \quad (\text{C.13})$$

A rise in the unskilled wage of 1% would increase the average wage by s_U %, where s_U is the share of the unskilled in total wages.²⁹ To keep the average wage constant, the skilled wage must *fall* by s_U/s_S % (making complementarity between occupations practically automatic for any value of θ). Therefore the relative wage of the unskilled has risen by $(1 + s_U/s_S)$ %. Their relative employment must fall by this amount multiplied by θ , the elasticity of substitution between skilled and unskilled labour. Noting that $s_U + s_S = 1$, we have

$$\% \Delta \frac{S}{U} = \frac{\theta}{1 - s_U}. \quad (\text{C.14})$$

²⁹ This follows from Shephard's Lemma, which states that the derivative of the cost function (average wage) with respect to the price of an input (unskilled wage) is equal to the demand for that input (unskilled employment).

As the share of the unskilled approaches zero, this approaches θ . As the share of the unskilled approaches one, this approaches infinity (in the limit, it is impossible to raise the unskilled wage when labour is entirely unskilled). Thus we see again that demand becomes more elastic as the share of wage income increases, even if this time it is only in relative terms.

To find the change in absolute terms, it is necessary to make some additional assumption about the supply of skilled labour. If it is completely inelastic, then we can simply say that the absolute percentage change in the employment of unskilled labour is equal to the relative change, so that the own-wage elasticity of demand for unskilled labour is

$$E_{uu} = \frac{\theta}{s_u - 1}. \quad (\text{C.15})$$

The symmetrical result for skilled labour seems less appropriate, since displaced skilled labour would probably move into the unskilled sector. Since the type of wage floors we consider are mostly binding on the unskilled, however, this caveat does not seem particularly important.

Capital-skill complementarity

In chapter C4, it was assumed that the relative demand for different occupations was exogenous i.e. that the a_i coefficients were constant with respect to all other variables within the model. This assumption does not rule out random or deterministic change over time from exogenous technological progress or other shocks. However, it is generally accepted that capital is a complement for skilled labour (Hamermesh 1993:135). As we saw in chapter A3, the standard method of modelling this complementarity is a production function that nests skilled and unskilled labour

asymmetrically e.g. $g[U, f(K, S)]$ where f and g are CES functions (Krusell et al 2000).

This method, however, requires quite a high elasticity of substitution between unskilled labour and the other factors. In trying to capture the effect of capital accumulation on the relative demand for skilled labour, we are forced to make an assumption that seems incompatible with the evidence in chapter C2.

Using a simplified version of the model developed in chapter A3, it is possible to incorporate capital-skill complementarity within the LCD function by allowing the relative demand for different occupations to change with the capital/labour ratio. Since this ratio is in turn a function of the average wage (given whatever assumption is made about the capital stock), we can write $a_i = a_i(W) \quad \forall i$. Then the occupational wage elasticity of demand E_{jk} from equation (C.3) must be recalculated as

$$\frac{w_k}{a_j L^D} \frac{\partial(a_j L^D)}{\partial w_k} = \frac{w_k}{a_j L^D} \left[a_j \frac{\partial L^D}{\partial W} \frac{\partial W}{\partial w_k} + L^D \frac{\partial a_j}{\partial W} \frac{\partial W}{\partial w_k} \right].$$

By implicitly differentiating (C.2) we find

$$\frac{\partial W}{\partial w_k} = \frac{a_k}{1 - \sum_{i=1}^n w_i \frac{\partial a_i}{\partial W}}.$$

Combining these expressions and rearranging gives

$$E_{jk} = s_k \left(E + \frac{W}{a_j} \frac{\partial a_j}{\partial W} \right) \left/ \left(1 - \sum_{i=1}^n w_i \frac{\partial a_i}{\partial W} \right) \right., \quad (C.16)$$

where s_k and E are the income share and average wage elasticity from equations (C.4) and (C.5). Raising the average wage by raising w_k now has two effects: it changes the relative demand for each occupation (the second term in brackets in the numerator is the elasticity of relative demand for occupation j with respect to the average wage) as well as reducing the total demand for labour. This new elasticity will tend to be larger or

smaller than $s_k E$ depending on whether $\frac{\partial a_j}{\partial W}$ is negative or positive, i.e. whether a higher capital-labour ratio raises or lowers the relative demand for a particular occupation. If the relative demand for skilled workers rises with the capital-labour ratio, one would expect the own-wage elasticity of demand to be smaller (less negative) in more skilled occupations. There is some evidence of this – see Hamermesh (1993:118,135). If $\frac{\partial a_i}{\partial W} = 0 \forall i$ then equation (C.16) reduces to (C.3).

Certain constraints must be imposed to keep the labour units sensible. If the wage in one occupation rises, *ceteris paribus*, the average wage should rise, i.e. $\frac{\partial W}{\partial w_k} > 0$

or

$$\sum_{i=1}^n w_i \frac{\partial a_i}{\partial W} < 1. \quad (C.17)$$

Perhaps a unit of labour should contain the same number of workers at every value of K/L . Then

$$\sum_{i=1}^n \frac{\partial a_i}{\partial W} = 0. \quad (C.18)$$

The first constraint (C.17) implies that the denominator of (C.16) is always positive. (C.18) implies that the denominator is equal to 1 if wages in all occupations are equal. If we suppose, however, that raising the average wage tends to raise the relative demand for occupations with higher wages (as seems likely with capital-skill complementarity), then the denominator would tend to be less than 1.

This extension of the LCD function preserves the properties that employment in all occupations depends only on the average wage, not relative wages, and that the own-wage elasticity of demand is proportional to the occupation's share of wage income. It

also preserves p-complementarity between occupations, as can be shown by considering the seemingly unrelated question of whether demand curves can slope up.

The revised elasticity in equation (C.16) seemingly leaves open the possibility that E_{jk} is positive. For any occupation j , this would require

$$E + \frac{W}{a_j} \frac{\partial a_j}{\partial W} > 0. \quad (C.19)$$

The elasticity of a_j (the number of workers of type j required for a single unit of aggregate labour L) with respect to the average wage must be positive and greater in absolute value than the elasticity of demand for aggregate labour, i.e. the relative demand for occupation j must increase faster than the aggregate demand for labour falls. This condition does not depend on which wage k rises since a wage rise in any occupation only matters insofar as it affects the average wage. So if a cross-wage elasticity (E_{jk} with $j \neq k$) can be positive, which is less intuitively unreasonable, so can an own-wage elasticity E_{jj} .

It can be shown, however, that an upward sloping demand curve is incompatible with profit maximisation. Consider a change in wages from $\{w_1, \dots, w_n\}$ to $\{w_1', \dots, w_n'\}$, which results in employment changing from $\{L_1, \dots, L_n\}$ to $\{L_1', \dots, L_n'\}$ and output from Y to Y' . Now if employers are profit maximising, it must be true that at the old wages, the old pattern of employment and output is more profitable than the new, and at the new wages, the new pattern of employment and output is more profitable than the old. Hence

$$Y - \sum_{i=1}^n w_i L_i > Y' - \sum_{i=1}^n w_i' L_i'$$

and

$$Y' - \sum_{i=1}^n w_i' L_i' > Y - \sum_{i=1}^n w_i' L_i .$$

Writing Δx for $(x' - x)$ gives

$$\sum_{i=1}^n w_i \Delta L_i > \Delta Y$$

and

$$\Delta Y > \sum_{i=1}^n w_i' \Delta L_i .$$

Combining the last two conditions implies

$$\sum_{i=1}^n \Delta w_i \Delta L_i < 0 . \quad (\text{C.20})$$

If only one wage j changes, the change in employment for j must be of an opposite sign. From the logic above, this implies that cross wage elasticities are also negative i.e. that different occupations are still p-complements.

Heterogenous skills

If one wishes to incorporate substitution between workers *within* occupations, it is possible to extend the basic LCD function so that workers within an occupation vary in their skill levels. For simplicity, we set $a_i = 1 \quad \forall i$ ³⁰ and also normalise aggregate employment to 1. Retain Equation (C.1) as a description of the *number* of workers in each occupation needed for a unit of labour, but define the effective labour input as a Cobb-Douglas function of the skill levels of each worker:

$$L = \prod_{i=1}^n S_i^{\frac{1}{n}} , \quad (\text{C.20})$$

³⁰ Without loss of generality since occupations can always be sub-divided e.g. violinists with $a=2$ into first and second violinists each with $a=1$.

where S_i measures the skill level of worker i . Then in a competitive labour market, assuming that a continuum of skills is available, the marginal product of skill in each occupation, $\frac{\alpha}{n} \frac{Y}{S_i}$, will be set equal to its marginal cost. More highly skilled workers will therefore enjoy higher wages.

This type of model seems relevant in considering all types of ‘superstar’ pay in sports, entertainment and business: the relevant calculation is not ‘what is the increase in revenue *with* a goalkeeper/soloist/CEO versus *without* one, all else equal?’, which is the usual marginal product calculation, but ‘what is the increase in revenue with *this* superior one vs. *that* inferior one?’ For example, Gabaix and Landier (2008) argue that rising CEO pay can be explained by the growing size of firms, which magnifies the absolute difference in profits under more versus less skilled managers. The counterfactual of a leaderless firm is not considered, indeed is rather absurd.

While this model restores the relevance of individual productivity to wages, a binding minimum wage will not reduce employment in the affected occupations relative to others, since this is still fixed by the definition of the labour units. It would, however, create an incentive to hire workers with a higher skill level in the occupation where the minimum was binding, if less skilled workers lose their cost advantage. Indulging in discrimination would also become cheaper. This is consistent with the common argument (e.g. Neumark and Wascher 2006) that racial minorities, the poorly educated, and teenagers are more likely to experience negative employment effects from minimum wages. The corollary is that negative employment effects for particular groups do not necessarily mean negative employment effects in the aggregate, since one kind of worker is simply being replaced by another. However, if the more highly skilled workers are recruited from other occupations, this could mean a drop in total

employment, without particularly affecting the occupation where the wage was raised.

The same effect could happen in the longer run if workers are diverted from education.

Summary

It has been shown in this chapter that the basic hypothesis of inelastic labour demand and labour-labour complementarity at an occupational level is compatible with a much richer range of phenomena than can be captured in the simple LCD function. More complex models that allow for realistic amounts of substitution between the products of different industries and different types of labour within industries, capital-skill complementarity, and heterogeneous skills within occupations, can still preserve the essential property of the simpler model – that changes in relative wages have very small or zero effects on relative employment. In the first two cases, p-complementarity and an increasing relationship between an occupation's share of wages and its own wage demand elasticity are simple to show as well.

CHAPTER C7. CONCLUSIONS

Wage floors are still widespread and politically popular, despite the abandonment of price controls in other areas of the economy. Furthermore, there is no consensus, either empirical or theoretical, about their employment effects. Empirical studies of minimum wages, equal pay laws and other wage setting institutions often fail to find significant negative effects, let alone of a consistent size. Theoretically, researchers have put forward various monopsony, efficiency wage and effective demand theories as alternatives to the price-taking 'neoclassical' model.

We have contended that the findings of insignificant employment effects should be taken seriously, but at the same time, the proposed explanations in the literature are unsatisfactory. Instead, we propose that the focus should be on the underlying substitution possibilities (or lack thereof) in production technology and consumer preferences, rather than some peculiarity of the employer-employee relationship. Specifically, we argue that the demand for labour at the level of individual occupations is much less elastic than the demand for labour in the aggregate. This is a hypothesis both about substitution elasticities, and the most relevant way of disaggregating 'labour'. It is unusual firstly in emphasising the heterogeneity of labour as an explanation for the insensitivity of employment to wages, and secondly, in disaggregating labour by occupation rather than personal characteristics. In other words, the focus is on the job being done rather than the age, sex or education of the worker doing it.

This hypothesis is modelled using a ‘Leontief/Cobb-Douglas’ production function. As with any aggregate production function, this specification should not be taken too literally. The question is whether it is a reasonable first approximation, and whether pretending the world works this way yields any useful insights.

The evidence presented in this paper suggests that it is and it does. This simple model explains a surprising range of otherwise puzzling empirical evidence. If the demand for labour in particular occupations is much less elastic than the demand for labour in the aggregate, it is no surprise that minimum wage and equal pay laws, and wage setting institutions that compress the wage distribution, have little apparent effect on employment.

The case is strengthened further when other aspects of the labour market are considered. Why do average wages seem to have a strong effect on employment when relative wages do not? Why do institutional wage floors produce more equal wages, but not larger wage shares? Why might collective bargaining by larger groups of workers produce wage moderation? Why are increases in labour supply resisted within occupations, but welcomed between occupations? Why are there complaints about skills shortages in boom times and structural unemployment in slumps? The technological hypothesis embodied in the LCD function provides an explanation for all of these facts. The other theories considered – mismeasurement, monopsony, efficiency wages and aggregate demand– not only have particular problems of their own, but are consistent with hardly any of these facts. Of course, these other theories are not thereby ruled out as potentially important features of the labour market. They are simply insufficient as an explanation for the particular question considered in this paper.

What policy implications follow from this view of labour demand? Most obviously, institutions that raise wages at the bottom of the distribution need not cost a

large number of jobs as long as they affect a small proportion of total wage income (which need not mean a small number of workers), or as long as increases at the bottom are matched by restraint elsewhere. This does not mean, however, that their effects are entirely benign. It merely means that the key questions are moved to the supply side. Will a raise in wages in one occupation attract workers from other occupations or from education, potentially displacing less skilled competitors and reducing the overall effective labour supply? Will it reduce incentives to acquire education and skills, with the same effects (albeit in a longer timeframe)? Will it reduce the hours worked by higher-wage individuals, resulting in a decline in demand for services provided by the less skilled?

Incidentally, this focus on supply may provide an answer to the questions with which this paper began. Why are price controls in the labour market more popular, and their detrimental effects less obvious, than price controls in product markets? Some of the answer may be on the demand side – if the elasticity of substitution between different types of labour is low, and if there are many different types, it is plausible that the elasticity of demand for each of them individually is lower than the elasticity of demand for the product they produce. Certainly, inelastic labour demand is a necessary condition for wage floors to have desirable effects, by any plausible standard. However, the demand for many product groups, particularly staple commodities, is also quite inelastic, yet price controls on these products have not been notably successful. The answer must surely be on the supply side: the supply of labour as a whole is generally considered to be fairly inelastic (some argue that it is even backward bending), while the supply of commodities is governed by their marginal cost. Aside from cases where there is a naturally limited supply with a great range of extraction costs (such as oil) it is

plausible that product supply is generally much more elastic than labour supply.³¹ This would also provide a reason for why labour supply has received so much attention and labour demand so little.

These are not radical policy views. Indeed, one of the main strengths of the hypothesis put forward in this paper is that its implications are so plausible. From a simple set of assumptions, it provides coherent reasons for a range of otherwise puzzling features of the labour market. If one has any faith in the powers of human reason or trial and error to produce more or less efficient institutions, and in the tendency of academic economists to select the most promising fields for study, then it should be highly reassuring that the persistence of price controls in the labour market, and the relative neglect of labour demand as a field of study, are not productive of large deadweight losses.

³¹ Even for oil, the supply to any individual oil importing country is clearly more elastic than the overall supply.

LAST WORDS

It would be presumptuous to claim that I have provided definitive answers to questions that have been considered by far more distinguished minds before me. Yet I hope that raking over these old coals has uncovered a few embers that are still glowing.

No single, definitive explanation has been advocated in this thesis for why wage inequality has recently been rising the most in those countries where wage shares have been falling the least. Capital accumulation and the behaviour of top wage incomes offer some promise, at least on the grounds of theoretical consistency, but do not seem to match the admittedly imperfect data that we have. The behaviour of the wage share is more puzzling than that of wage inequality, which seems to fit reasonably well the institutional explanations put forward in the literature, perhaps supplemented with a role for education. Yet the lack of an obvious explanation should make the puzzle more rather than less interesting. If rising wage inequality and falling wage shares are considered worthy of extensive attention, surely a strong and previously unnoticed relationship between the two trends is also of interest. That the same explanations have been commonly put forward for both trends makes the observed correlation between them even more surprising.

The notes regarding labour demand elasticities and immigration may seem to be of fairly specific and limited applicability. Yet they contain a more general message: labour being a derived demand, an accurate estimate of a single parameter (which can be difficult enough to obtain) is almost never sufficient in order to answer a question of practical interest. Refinements of such estimates (e.g. of the elasticity of substitution

between capital and aggregate labour, or immigrant and non immigrant workers within a particular education and skill class) are often less important than the explicit or implicit assumptions lurking in the background (that a microeconomic formula developed for individual industries can be applied to an entire country, or that the rate of return on capital will remain constant despite an increase in the rate of growth of the labour force).

On the final question, the apparent insensitivity of employment to relative wages, we have made a more definite argument. Rather than concentrating on the peculiar features of the employment relationship, it is worth taking another look at the substitution possibilities in production technology and consumer preferences, particularly with regards to the division of homogeneous 'labour' into different occupations. A focus on the work being done may be more fruitful for these purposes than the personal characteristics of individual workers. We have seen that this approach is consistent with plausible values of substitution elasticities, as well as being a better fit than its competitors to many stylized facts about the labour market.

A final note on methodology may be in order. The studies in this volume might seem somewhat unsatisfactory, by contemporary standards, in the nature and quality of the evidence used, the multiplicity of theories considered, and the tentative nature of their conclusions. It is worth reminding ourselves that decisive experiments between two (and only two) contending theories are a beautiful and rare thing even in the natural sciences. While we should take maximum advantage of any such opportunity afforded us by history (or generous funding of randomised trials), we must also accept that, on some important questions, these opportunities come rarely or not at all. In these situations, we must fall back on circumstantial evidence from as wide a range of sources as possible, and accept the consequent diminution in the certainty and precision of our

knowledge. This approach, with all its limitations, seems superior to pure, corrosive scepticism, reliance on ever more baroque theories which can only be calibrated rather than tested, or refusal to grapple with the questions at all.

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